The PSYCHOLOGICAL RECORD

VOLUME
V
1941-1945

THE PRINCIPIA PRESS, INC.
BLOOMINGTON, INDIANA

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The
PSYCHOLOGICAL RECORD . . . .

NOVEMBER, 1941
Vol. V No. 1

EXPERIMENTAL DATA ON THE PROBLEM OF MOTOR LATERAL DOMINANCE IN FEET AND HANDS

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THE PRINCIPIA PRESS, INC.
BLOOMINGTON, INDIANA

Price of this number, $1.25

EXPERIMENTAL DATA ON THE PROBLEM OF MOTOR LATERAL DOMINANCE IN FEET AND HANDS[1]

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1. *History of the Problem.*

The history of the problem will be limited to a consideration of available material on footedness since many summaries of material upon handedness have already been made. Downey (1) offers a very good treatment of the data on footedness: "Schaeffer (7) concluded from a study of data at hand that the right leg is longer in about 52 percent of humans. Lund (6) measured the length of the legs as a test of dominance and reported 39 percent of left-dominance, 33 percent of right-dominance and 28 percent of equality. If one can infer functional dominance from structural dominance, left-footedness is much more common than left-handedness. Crossed asymmetry, that is, longer arm on one side associated with longer leg on the other has been reported as common by a number of anthropologists. Downey's (2) figures seem to indicate that the hand down on the spade follows the spade foot. In such bimanual operations as spading and shoveling, footedness certainly deserves consideration.

"Lund (6) believes correspondence between functional and structural dominance the simple and natural explanation for the typical veering from a straight course that results when a man attempts to walk a course blindfolded. In a carefully planned experiment on 125 subjects, measurements were obtained for handedness, eyedness, length of arms and legs, and posture and the degree of correspondence with right or left veering calculated. Superior structural development of the right leg in left veering subjects and vice versa, was found in 'four out of every five subjects'."

[1] Recommended by Dr. C. N. Louttitt, October 20, 1941.

Haefner (4) has recently reported on the hand and foot tendencies of children. Four foot tests were used, namely: stepping off, stepping up, kicking and pressing down with the foot on a wad of paper. These were given to 136 children of whom half were left-handed. He reports that only a small percentage of children show foot dominance and coefficients between hand and foot tests were likely to be low. The unimanual activities are rather highly correlated with the foot activities of kicking and pressing down but show the results of considerable modification in their relation to the foot activities of stepping off and stepping up. Unimanual activities show a somewhat higher degree of correlation with foot activities than do bimanual activities. Haefner used his test of pressing down to provide a measure of the spade foot with considerable chance of error.

Eyre (3) points out the need for working out criteria for testing footedness. This author believes that hand-foot correspondence is found more often than hand-eye correspondence and hand-eye correspondence than eye-foot correspondence. Cross-laterality is believed to be associated more often with mentally subnormal, psychotic and the emotionally unstable than the normal.

Two rather pertinent suggestions are made by Kounin (5) and Wentworth (8). On the basis of experimental data drawn from 19 rats, Wentworth draws the tentative conclusion that forced early unilateral reaching has a real effect upon the hand used in later reaches. Kounin finds from experimental testing of rhesus and cebus monkeys that the degree of preferential handedness manifested depends upon the nature of the task performed. The most effective tests are those requiring a considerable degree of difficult, co-ordinated and delicate manipulation. Relatively unskilled performances revealed less marked and less consistent handedness. The greater preferential handedness of the cebus monkey may have been due to their greater tendency to investigatory and manipulative behavior.

Yerkes (9) observes that very little data upon laterality of apes and chimpanzees exists. The inference might be that such data was not very striking. He quotes Mollison for evidence that skeletal measurements show the gibbon, orang-outan and man to be naturally right-handed and the gorilla and chimpanzee left-handed. Mollison

is further quoted as stating that all three bones of the leg predominate easily on the right side in the orang and gibbon and on the left in the gorilla. Fick, however, is quoted by Yerkes to show that chimpanzees are ambidextrous. Yerkes himself believes the orang-outan is not predominatly either left- or right-handed but often shows preference for one or the other hand. He cites one clear case of a left-handed male orang-outan. The chimpanzee may be either right- or left-handed, for hand preference may vary from time to time in accordance with the nature of the activity in point. Yerkes experimented on the 5 year old gorilla, Congo, for data on maximal arm and leg reach and the use of tools. She used the right hand and arm about two-thirds of the time. She reached for near things with the right arm and hand and for far things with the left leg and foot. Yerkes conducted some experiments on eyedness and found that a right handed chimpanzee made 58.3% correct choices with the right eye and 48.7% with the left eye alone.

Data upon preferential use of feet is inadequate and trends of thought somewhat conflicting. Careful extended research to accumulate reliable data on this aspect of the problem of lateral dominance is needed.

2. *The Problem.*

The primary purpose of this investigation was to accumulate a large amount of experimental data upon the extent and nature of lateral dominance in feet in motor activities. Since foot coordinations are probably less affected by training than hand coordinations, such data should contribute evidence upon the possibility of inherent preferential use of one side of the body. On the basis of such data better measures of laterality might be discovered for subsequent individual analysis. To establish relationships with footedness in the individual case, much material upon preferential use of hands, eyes and ears was accumulated in the course of the study.

3. *Technique of Experimentation.*

Some general facts concerning the testing should be mentioned. For the gross measures of footedness, eight tests were used, such as stepping up, kicking a ball and hopping on one leg. Ten specific

tests of small coordinations of toes were also given. Seven of the specific tests were done with vision; these involved some rather simple movements like tapping and carrying marbles as well as more complicated ones with pegboards and formboards. Three of the specific tests were done without vision, one involved simple movements and the other two involved rather complicated ones. For the sake of clearness the individual tests will be described in detail along with the consideration of the results.

For the gross measures of handedness ten tests, such as cutting, shoveling and putting on clothing, were made. Two specific tests of handedness were made with vision and two without vision. Several observations of the eyes were made in the cone and peephole tests and in winking. The preferred ear in listening was also recorded.

The odd-numbered subjects began all tests with the left foot while the even-numbered ones began with the right foot. In the specific tests of hands and feet, six trials were given with the left and right members alternating. The performance time and the paired difference, that is, the number of seconds one foot was quicker than the other in a given pair of trials or in several pairs of trials, were bases of comparison. The first two trials, that is, one with each foot, were considered as a practice exercise and not counted in final results.

4. *The Subjects.*

Of the 190 subjects used, 3 were not in college, 20 were graduate students and the others were undergraduates. On each test the sexes were equally represented with a few exceptions. The age range was from 18 to 56 years. Between 20 and 30 years of age there were 172 subjects and most of these were under 25 years of age. There were 11 subjects between 31 and 40, 6 between 41 and 50 and 1 over 50. Subjects usually did about half the tests in one hour. One group of 100 students took all the specific tests with vision. The second group of 90 students took most tests without vision and the Sequin formboard test with vision. Sixty-eight subjects were the same for the two groups of tests. This gave an excellent basis of comparing the various tests as measures of laterality.

5. *The Results of Foot Tests.*

(1) Gross Tests of Laterality.

These tests of gross total motor activities like kicking a ball and stepping up were given to about 90 students. Occasionally an item was overlooked in the test situation; this accounts for the variation in numbers of subjects on the different tests. In the 3 tests of kicking a ball, hopping on one foot and stepping up onto a chair, the right foot was preferred 60 or more percent of the time by all subjects. The left and right legs were about equally favored for the tests of stepping down from a chair, taking the first shoe off, putting the first leg in overalls, spading and putting on the first stocking. For further details on these tests see Table I.

In these tests some interesting sex differences appeared. Two factors should be kept in mind as one considers these differences. Men probably engage in more activities and sports involving the right arm; hence they develop the left leg better for good balance. The fact that women have a more difficult task to dress and undress the feet, probably affects several of the tests. Both sexes favored the right foot for hopping and kicking, the women slightly more often than the men. In the other activities men used either foot about equally or slightly favored the left foot. This use of the left foot probably reflected the practice effects of sports since men were quicker with the right foot than the left in 6 of the 7 specific tests described in the next section. Women showed a greater preference for the right foot than men in each of the gross tests. Both women and men tended to completely dress or undress the foot with which they started the procedure, an economical procedure in point of time and movement. Fifty-three percent of the women took off the right shoe first and 51 percent of these then took off the right stocking. Forty-seven percent of the women took off the left shoe first and only 31 percent of these then took off the left stocking. In this activity women again showed a slight preference for the right. Of the men 45% took off the right shoe first and 32% of these then took off the right sock. Fifty-five percent of the men took off the left shoe first and 30% of these then took off the left sock. Eighteen percent of the women and 39% of the men did not completely undress the foot with which they started the procedure but

TABLE I.

Lateral Preference for Feet on Gross Motor Tests.

Test	Women						Men						All Cases					
	Number of cases			Per cent of cases			Number of cases			Per cent of cases			Number of cases			Per cent of cases		
	L	E*	R	L	E	R	L	E	R	L	E	R	L	E	R	L	E	R
1. Kicking a ball	2	1	38	5	2	93	4	2	38	9	5	86	6	3	76	7	4	89
2. Hopping on one foot	15	–	30	33	–	67	16	–	26	38	–	62	31	–	56	36	–	64
3. Stepping up	12	–	33	27	–	73	24	–	21	53	–	47	36	–	54	40	–	60
4. Stepping down	14	–	27	34	–	66	26	–	19	58	–	42	40	–	46	47	–	53
5. First shoe off	43	–	49	47	–	53	48	–	40	55	–	45	91	–	89	51	–	49
6. Leg in overalls	19	–	23	45	–	55	25	–	20	56	–	44	44	–	43	51	–	49
7. Spading	22	–	23	49	–	51	24	2	18	55	5	40	46	2	41	52	2	46
Average				34		65				46		52				41		59

* either foot.

removed both shoes. Of the women 16% and 40% of the men did not completely dress a foot but put on both socks first. Women probably completed one foot more often than men because this was a greater saving of energy for them. This was an interesting incident since it showed so well how a very minor factor determined the selection of a foot in an activity.

To summarize sex difference on gross motor foot tests, women showed greater preference for the right foot on all seven tests with an average of 65% of cases favoring the right foot and 34% favoring the left. Men on the other hand preferred the right foot in only 2 of 7 tests and showed an average of 52% favoring the right foot and 46% the left foot.

The gross motor tests for both sexes combined gave no clear preference for either foot. Although the right was preferred in only 3 of the 7 tests, an average of all cases for the 7 tests showed the left preferred by 41% of the cases and the right by 59%. With the omission of the first test this average became 46% of cases for the left and 54% for the right. Three of the 7 responses have many similar elements with quite different foot preferences. For example, 89% of cases kicked the ball with the right foot, only 49% placed the right leg into overalls and only 46% spaded with the right foot. The great preference for the right foot in the first reaction was probably due to teaching and preference for the right hand in holding the ball. Of the 6 cases using the left foot to kick, 4 had distinct preference for the left hand. Stepping up with the right foot was found in 60% of cases and down in 53%. In the first of these two reactions one probably practices stepping up to grasp something with the right hand while stepping down was not so modified.

Gross motor tests were readily modified by handedness. Results from such tests tended to give the impression of lateral preference as a dichotomy rather than a gradation. They failed to differentiate the feet very clearly. For these reasons gross motor tests were not considered good measures of lateral preference in feet.

(2) Specific Measures of Feet With Vision

Various specific measures of feet were designed to measure both the more simple and the more complex movements of the toes and

feet. Test materials and tests results were considered together for the sake of clearness to the reader.

The equipment for the first or tapping test was a telegraph key connected to an electric counter. The big toe was placed on the key with the heel firmly placed on the floor. The entire foot participated

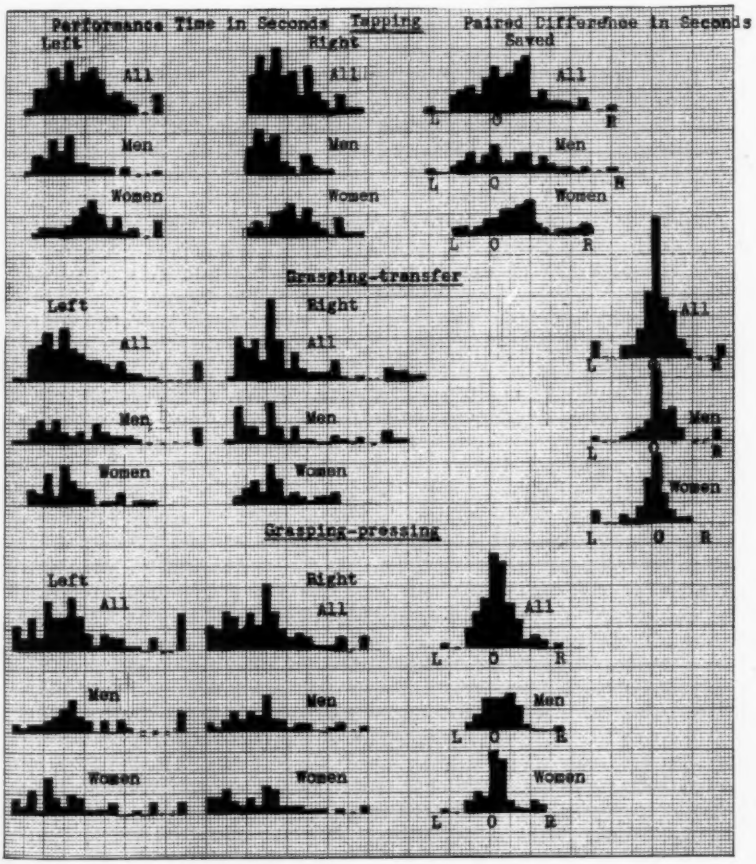

Fig. 1. Group Performance on Motor Foot Tests.

TABLE II.

Summary of Mean, Median and Sigma for Laterality Tests of Motor Type

Test	Number of Cases			Left						Right											
				Men			Women			Total			Men			Women			Total		
	M	F	T	Mean	Mid.	Sigma	Mean	Mid	Sigma	Mean	Mid.	Sigma	Mean	Mid.	Sigma	Mean	Mid.	Sigma	Mean	Mid.	Sigma
Foot Tests																					
Vision																					
1. Tapping	50	50	100	72.8	69	16.3	87.3	86	18.3	79.8	77	16.2	67.0	64	12.9	81.2	78	18.3	74.1	70	17.5
2. Grasping transfer	50	50	100	61.4	50	41.7	54.1	49	26.7	57.7	49	35.2	54.8	48	30.1	63.6	50	43.9	59.4	48	37.8
3. Grasping pressing	47	50	97	63.7	59	29.4	58.5	50	30.2	61.3	56	30.1	56.9	56	21.2	56.0	55	29.0	56.5	56	25.5
4. Grasping throwing	45	49	94	30.8	25	21.8	37.6	36	13.7	34.4	32	18.4	26.6	23	16.4	37.5	34	18.9	33.2	31	17.6
5. Manipulation	37	46	83	69.3	66	24.5	76.2	71	29.1	72.9	67	27.4	64.2	61	20.9	68.3	63	22.9	66.2	61	22.2
6. Wallin pegboard	50	50	100	138.0	130	48.9	154.6	135	66.2	146.1	132	58.8	131.2	123	51.1	132.6	127	38.9	131.6	124	45.2
7. Seguin Formboard	45	45	90	71.9	66	23.8	80.1	78	16.8	75.9	73	20.9	76.4	69	21.1	80.5	77	14.8	78.5	74	18.4
No Vision																					
1. Pressing	45	45	90	29.9	29	8.6	33.4	33	9.3	31.7	31	8.9	31.1	29	9.5	33.0	33	9.4	32.1	31	9.5
2. Grasping	45	45	90	147.9	135	68.0	141.8	131	61.4	144.9	135	64.9	145.2	117	77.1	135.2	124	62.9	140.2	122	70.3
3. Manipulation	45	45	90	229.2	194	127.3	202.9	193	74.5	216.0	194	104.2	198.6	161	93.3	163.4	145	60.9	181.0	151	80.5
Average				91.5	82	41.0	92.7	86	34.6	92.1	85	38.5	85.2	75	35.4	85.1	79	32.0	85.3	77	34.5
Hand Tests																					
Vision																					
2. Sequin										67.6	67	13.8	54.5	52	12.9	67.6	66	12.5	60.5	61	14.2
1. Tapping	50	50	100	61.7	61	11.5	74.7	73.5	12.7												
Formboard	45	45	90	29.9	30	5.4	32.3	31	4.8	31.0	31	5.4	30.4	31	5.3	33.0	33	5.9	31.7	31	5.7
No Vision																					
1. Grasping transfer	45	44	89	88.1	71	46.1	71.6	68.5	22.5	79.9	71	37.3	82.2	70	37.9	75.4	71	23.7	78.8	70	31.8
2. Sequin Formboard	45	45	90	162.2	133	92.5	185.2	152	99.7	173.7	147.5	96.8	168.6	138	129.8	170.4	167	72.9	169.5	140	95.3
Average				85.2	73.7	38.9	90.9	41.2	34.9	88.1	79.1	38.3	83.6	75	46.5	86.6	84.2	28.7	85.1	76	36.7

in the movement. The basis of comparison was a time record for tapping 300 taps in four groups of 75. From Tables II and IV the mean performance for 100 cases was 74.1 seconds for the right with a sigma of 17.5 and 79.8 seconds for the left foot with a sigma of 16.2. Tables III and IV give the actual performance time for individual subjects. For the group 31% were quicker with the left foot and 62% with the right. For those quicker with the left foot the average saving was 8.1 seconds while the average saving for right feet was 13.3 seconds. The left foot was more often irregular and spasmodic in performance than the right with greater variability of pressure in the taps. Tables V and VI should be referred to.

In the first column of Figure 1 are the graphs of performance time for all left feet, based on Tables III and IV and underneath this are the graphs of the left feet for men and the left feet for men and the left feet for women. In the second column of this figure is the graph for all right feet with the graphs for men and women underneath. In the third column of this figure is the graph of paired differences in terms of seconds saved by the quicker foot over the performance time of the slower foot, based on Tables III and IV for all subjects with the graphs for the sexes underneath. The graphs of the third column of Figure 1 range from maximum left differences through zero to maximum right differences.

In comparing the sexes on this test women were slower than men with both feet. The mean for the right feet of men was 67 seconds with a sigma of 12.9; the mean for women was 81.2 seconds with a sigma of 18.3. The mean for the left feet of men was 72.8 seconds with sigma of 16.3; this mean for women was 87.8 with a sigma of 18.3. From Table V 24% of women and 38% of men were quicker with the left while 72% of women and 52% of men were quicker with the right foot. This test showed very well the great effect of practice in the case of men for good left performance.

The grasping-carrying test was to pick up and transfer 10 three-quarter inch marbles from one dish to another one 12 inches away. The dishes were about ¾ of an inch deep with a top diameter of 5½ inches and a bottom one of 4 inches. Marbles were usually carried between the three middle toes and the ball of the foot. This part of the foot was so insensitive that nearly every subject made

Average 85.2 73.7 38.9 90.9 41.2 34.9 88.1 79.1 38.3 83.6 75 46.8 86.6 84.2 28.7 85.1 76 36.7

TABLE III.

Performance Time for Men on the Foot Tests with Vision in Terms of Seconds

No. of Subject	Tapping		Grasping —Carrying—		Grasping —Pressing—		Grasping —Throwing—		Manipu- —lation—		Wallin —Pegboard—	
	L	R	L	R	L	R	L	R	L	R	L	R
1.	55	55	19	28	39	49	12	18	38	34	99	123
2.	54	50	39	26	49	64	18	18	—	—	105	121
3.	61	64	32	36	91	83	20	23	—	—	121	134
4	63	67	147	63	87	103	52	52	—	—	297	259
5	51	51	58	27	42	42	17	16	—	—	163	163
6.	108	88	266	137	180	100	—	—	—	—	235	208
7.	67	58	75	52	34	39	—	—	—	—	176	131
8.	73	54	80	61	58	58	35	23	58	50	102	193
9	68	76	41	38	121	101	42	32	—	—	125	111
10	98	93	40	36	79	48	17	14	—	—	132	129
11.	72	86	34	46	33	23	18	23	—	—	74	86
12.	67	92	54	53	115	77	38	49	—	—	170	140
13.	105	87	36	23	53	45	23	17	102	90	338	127
14.	62	56	39	34	54	64	15	16	57	77	130	78
15.	65	61	70	41	59	56	20	15	66	60	85	66
16.	134	69	116	110	67	59	27	16	71	104	158	227
17.	62	54	48	45	—	—	—	—	—	—	174	100
18.	92	59	84	86	23	48	20	35	100	93	144	194
19.	66	54	176	91	—	—	—	—	—	—	186	106
20.	74	56	32	28	59	56	19	15	64	45	124	105
21.	64	64	25	25	48	37	16	18	72	75	109	83
22.	50	51	30	33	69	58	18	12	41	47	54	127
23.	70	61	55	64	44	31	33	37	68	61	145	139
24.	61	62	46	48	54	59	16	21	71	54	76	82

No. of Subject	Tapping		Grasping —Carrying—		Grasping —Pressing—		Grasping —Throwing—		Manipulation		Wallin —Pegboard—	
	L	R	L	R	L	R	L	R	L	R	L	R
25.	70	70	74	47	53	48	19	19	72	52	168	120
26.	59	69	66	66	59	60	37	52	63	102	103	80
27.	89	67	64	47	114	117	45	22	79	52	159	295
28.	54	63	51	146	29	58	23	40	69	76	91	123
29.	81	75	43	33	63	48	17	13	41	58	164	145
30.	83	67	90	74	48	52	28	37	105	68	134	167
31.	53	58	32	35	—	—	—	—	—	—	147	122
32.	77	88	69	48	79	55	38	32	101	69	149	163
33.	94	68	44	33	59	38	28	26	66	69	169	100
34.	65	57	72	49	65	38	22	18	45	35	97	66
35.	61	68	44	44	57	66	28	21	46	56	141	104
36.	74	51	28	29	37	39	33	29	33	40	80	68
37.	70	60	47	62	53	22	18	29	48	39	113	124
38.	99	101	23	25	47	30	38	32	66	81	127	133
39.	75	58	76	58	89	64	140	53	56	49	171	250
40.	58	58	29	48	57	73	18	14	46	38	139	99
41.	59	72	65	86	61	45	54	71	141	64	130	121
42.	62	65	57	47	88	69	60	45	86	53	103	104
43.	80	68	68	105	78	58	39	35	67	65	117	183
44.	77	66	86	117	24	32	65	82	56	69	132	87
45.	70	59	39	53	61	70	30	31	84	64	119	144
46.	47	58	30	26	44	53	22	18	63	61	96	69
47.	71	85	40	49	52	76	25	20	60	75	70	73
48.	74	61	69	50	116	84	32	16	109	71	121	152
49.	87	96	88	117	70	53	35	42	105	122	90	85
50.	64	74	27	29	59	31	16	21	31	32	126	116
Average	73	67	61	55	64	57	31	27	69	64	138	131

TABLE IV.

Performance Time for Women on the Foot Tests with Vision in Terms of Seconds

No. of Subject	Tapping		Grasping —Carrying—		Grasping —Pressing—		Grasping —Throwing—		Manipulation		Wallin —Pegboard—	
	L	R	L	R	L	R	L	R	L	R	L	R
51.	102	88	40	36	81	27	31	32	71	73	134	141
52.	76	72	50	48	63	49	24	17	—	—	143	135
53.	67	67	28	33	50	80	23	15	49	39	254	143
54.	87	88	82	89	32	45	52	73	—	—	131	167
55.	94	89	35	31	42	33	18	18	—	—	117	113
56.	87	80	37	37	64	66	46	60	—	—	295	215
57.	85	77	50	46	28	41	54	33	70	42	131	96
58.	63	66	82	82	85	84	42	30	55	52	98	116
59.	77	64	37	39	49	35	36	35	55	56	159	147
60.	86	77	29	27	32	34	17	14	50	45	135	162
61.	89	78	71	277	47	47	24	146	80	114	188	194
62.	59	53	49	50	82	79	43	21	55	37	129	94
63.	91	86	45	75	138	88	45	24	112	97	108	124
64.	130	92	38	42	143	129	22	36	87	88	363	203
65.	73	85	45	57	146	104	26	32	75	86	210	154
66.	53	59	34	47	53	38	50	52	51	44	154	117
67.	81	83	55	44	45	63	47	44	94	72	171	223
68.	63	59	33	46	51	51	24	48	61	61	128	135
69.	88	92	53	42	61	60	55	36	105	79	153	119
70.	128	113	91	88	98	91	45	38	87	54	125	161
71.	73	67	94	72	35	23	60	71	80	51	124	103
72.	122	126	51	63	44	58	42	41	132	79	242	167
73.	73	73	83	48	44	35	76	32	152	73	145	123
74.	79	70	37	46	22	26	29	19	61	46	149	107

No. of

No. of Subject	Tapping		Grasping —Carrying—		Grasping —Pressing—		Grasping —Throwing—		Manipulation		Wallin —Pegboard—	
	L	R	L	R	L	R	L	R	L	R	L	R
74.	79	70	37	46	22	28	29	19				
75.	79	66	28	34	32	63	33	30	52	58	78	86
76.	85	77	61	54	110	54	33	39	96	80	346	196
77.	103	75	47	50	25	27	51	69	64	64	83	67
78.	112	111	35	37	41	62	30	24	42	55	258	126
79.	114	111	49	85	106	61	39	27	75	61	160	97
80.	107	122	34	29	31	35	32	23	56	71	95	91
81.	96	85	56	54	75	56	30	34	114	82	237	162
82.	91	86	48	39	70	38	45	37	51	42	88	89
83.	83	75	37	47	56	57	36	34	55	66	142	145
84.	102	114	75	167	43	63	34	38	132	81	84	132
85.	84	54	40	80	77	71	50	55	56	95	122	96
86.	85	72	186	161	108	60	—	—	155	126	228	141
87.	59	75	39	35	28	21	45	45	71	82	85	123
88.	98	95	47	50	56	58	26	40	74	56	88	132
89.	104	110	45	46	34	62	20	22	39	47	110	96
90.	100	96	49	69	24	29	22	24	53	66	111	102
91.	68	65	51	52	59	75	64	47	130	84	194	96
92.	75	64	50	32	41	39	44	39	53	55	139	127
93.	80	69	61	79	65	57	46	34	54	48	123	114
94.	89	71	45	64	57	184	42	25	83	59	227	154
95.	84	93	55	65	36	25	29	26	96	95	131	110
96.	91	81	102	173	43	47	50	53	72	77	177	127
97.	80	70	28	51	42	31	16	21	67	52	67	62
98.	121	84	63	46	49	68	44	36	52	48	97	100
99.	83	59	64	59	21	23	33	36	53	57	100	164
100.	90	78	59	49	59	48	21	21	79	146	174	237
Average	89	81	54	64	59	56	38	38	76	68	155	133
Average for all	80	74	58	59	61	57	34	33	73	66	146	132

several trips to the other dish without a marble, much to the disgust and surprise of the subject. The control over the toes was so poor that many subjects could not drop the marbles after they had carried them over to the other dish. They were removed only by drawing the bottom of the foot over the edge of the dish. If the marbles were dropped on the way to the other dish, these were returned to the original dish by the experimenter. Many parts of the body participated in the effort of the toes to pick up the marbles. Fingers would be alternately clenched and then spread wide. Head and trunk would bend forward with each effort to grasp the marbles. Occasionally the toes of the other foot would participate in the movement.

From Tables II and IV the mean performance for the 100 cases was 59.4 seconds for the right with a sigma of 37.8 and 57.7 seconds for the left foot with a sigma of 35.2. For the group 48% were quicker with the left with an average saving of 20.8 while 47% were quicker with the right with an average saving of 17.6 seconds. Tables V and VI will give more detailed information.

In comparing the sexes, men were quicker than women with the right foot. The mean for the right feet of men was 54.8 seconds with a sigma of 30.1; the mean for women was 63.6 with a sigma of 43.9. The mean for the left feet of men was 61.4 with a sigma of 41.7 seconds; the mean for women was 54.1 with a sigma of 26.7. As Table V shows, 40% of the men and 56% of the women were quicker with the left while 54% of the men and 40% of the women were quicker with the right. In terms of average seconds saved men's right feet were quicker than left feet by about 7 seconds on the average while women's left feet were quicker than right feet by about 4.6 seconds with two extreme cases omitted. Men averaged 14.5 trips for both the left and right feet while women averaged 14.5 trips with the left and 15.5 trips with the right. In this test the left foot probably had two advantages. The left foot moved in the more practiced direction left to right while the right moved in the less practiced direction right to left. The less tense foot would actually be able to carry more round objects. Men showed no difference in number of trips since both feet were well developed in motor activities while women's left feet were less well developed than the right feet and thus could carry more marbles.

TABLE V.

The Number and Per Cent of Cases with a Quicker Performance with the Left and Right Feet on Various Tests

Test	Left						Right					
	Men		Women		Total		Men		Women		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. Tapping	19	38	12	24	31	31	26	52	36	72	62	62
2. Grasping-carrying	20	40	28	56	48	48	27	54	20	40	47	47
3. Grasping-pressing	18	38	22	44	40	41	27	57	26	52	53	55
4. Grasping-throwing	18	40	19	39	37	39	24	53	27	55	51	54
5. Manipulation	15	41	17	37	32	38	22	59	27	59	49	59
6. Wallin pegboard	20	40	18	36	38	38	29	58	32	64	61	61
7. Seguin formboard	29	64	23	51	52	58	15	33	21	47	36	40
8. Pressing	24	53	20	44	44	49	20	44	23	51	43	48
9. Grasping	21	47	20	44	41	46	23	51	25	56	48	53
10 Manipulation	16	36	14	31	30	33	29	64	31	69	60	67
Average		43.7		40.6		42.1		52.5		56.5		54.6

TABLE VI.

Comparison of Left and Right Feet of Subjects in Terms of Seconds Saved with the Preferred Foot in Paired Trials in Performance with Vision

	Tapping			Grasping —Transfer—			Grasping —Pressing—			Grasping —Throwing—			Manipu- —lation—			Wallin —Pegboard—		
	R	L	E*	R	L	E	R	L	E	R	L	E	R	L	E	R	L	E
								Men										
No. cases	26	19	5	27	20	3	27	18	2	24	18	3	22	15	0	29	20	1
Average saving	15.6	8.4	..	23.3	15.9	..	20.0	11.1	..	10.4	8.4	..	18.3	13.7	..	36.9	35.9	..
								Women										
No. cases	36	12	2	20	28	2	26	22	2	27	19	3	27	17	2	32	18	0
Average saving	11.6	7.5	..	10.0	24.3	..	19.3	17.2	..	10.7	22.7	..	22.5	14.3	..	49.3	26.5	..
								All Cases										
No. cases	62	31	7	47	48	5	53	40	4	51	37	6	49	32	2	61	38	1
Average saving	13.3	8.1	..	17.6	20.8	..	19.7	14.5	..	10.6	11.6	..	20.6	14.0	..	43.4	31.4	..

* Equal

The grasping-pressing test utilized a pie tin, placed at a 45 degree inclination with a round hole 1¼ inches in diameter in the upper half of the tin. The task was to grasp or roll 10 three-quarter inch marbles from the bottom half of the tin upward through the small hole at the top. Three methods were used by subjects with the one restriction that the same method be used in a pair of trials. Some subjects carried the marbles on top of the foot with the foot pressed close to the tin; this method may have favored the right foot since the steadier control in this foot caused less marbles to be lost off the top of the foot. Some subjects carried the marbles upward under the toes and pressed them through the opening. Some feet rolled the marbles upward using the bottom of the foot and the heel.

From Tables II and IV the mean performance for the 97 cases was 56.5 seconds for the right with a sigma of 25.5 and 61.3 seconds for the left feet with a sigma of 30.1. From Tables V and VI 41% of cases were quicker with the left with an average saving of 14.5 while 55% were quicker with the right with an average saving of 19.7 seconds.

The sexes differed little in performance of the right feet but women were slightly better with the left than men. The mean for the left feet of men was 63.7 seconds with a sigma of 29.4; this mean for women was 58.5 seconds with a sigma of 30.2. The mean for the right feet of men was 56.9 seconds with a sigma of 21.2; this mean for women was 56 seconds with a sigma of 29.0. In terms of seconds saved 38% of the men and 44% of women were quicker with the left while 57% of men and 52% of women were quicker with the right. In terms of average seconds saved men's right feet were quicker than left ones by 9 seconds while women's right feet were quicker than left ones by 5 seconds.

The grasping-throwing test involved the picking up of 8 rubber drain stoppers of 1⅜ inches in diameter with the toes and throwing them into a hole 5½ by 5¼ inches at a distance of 15 inches. This was not easy since only 6 perfect scores were obtained in 376 trials. Although only one subject could not pick up the stoppers, many showed much strain in the form of tension in the hands and the toes of the other foot as well as by bending movements of the body with each gripping movement of the toes. Men had the advantage of

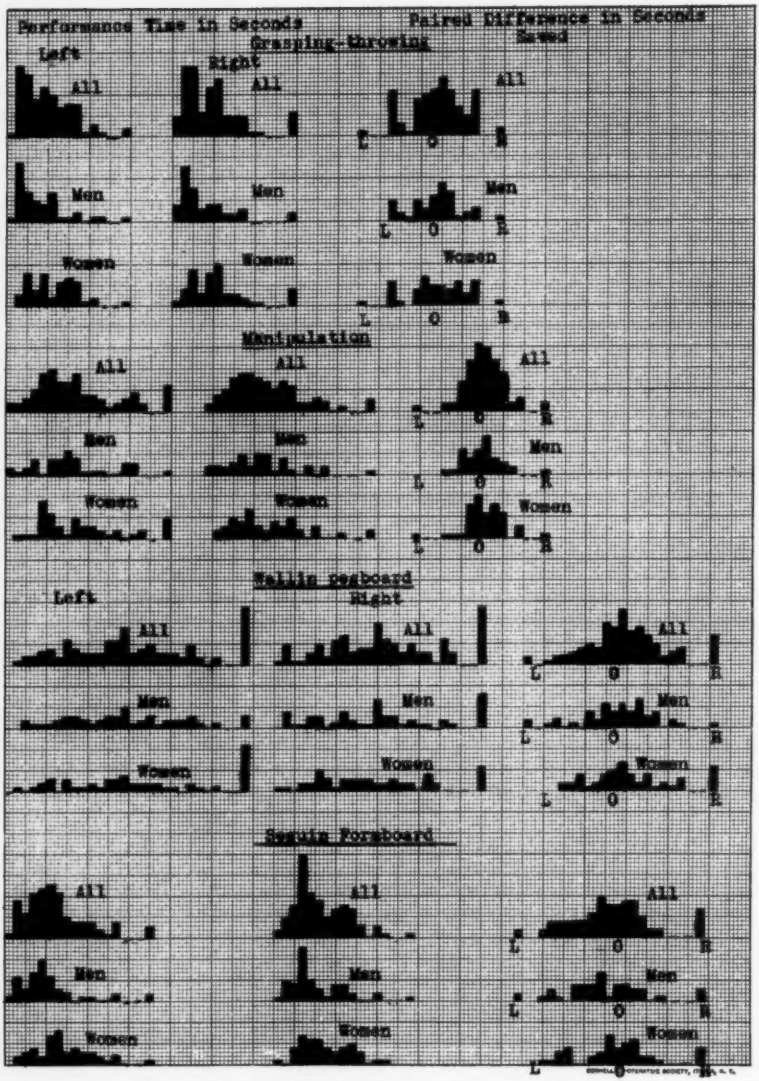

Fig. 2. Group Performance on Motor Foot Tests

larger toes to pick up the rubbers and greater practice in aiming. The aim was often spoiled because the person could not let go of the rubbers at the proper moment when the foot was tossed forward.

From Tables II and IV the mean performance for the 94 cases was 34.4 seconds for the left side with a sigma of 18.4 and 33.2 seconds for the right side with a sigma of 17.6. As Tables V and VI show 39% of cases were quicker with the left with an average saving of 11.6 seconds while 54% were quicker with the right with an average saving of 10.6 seconds. Figure 2 should be considered also.

In comparing the sexes men's feet were distinctly superior in terms of speed and accuracy over women's. The left mean for men was 30.8 seconds with a sigma of 21.8 and the left mean for women was 37.6 seconds with a sigma of 13.7. The right mean for men was 26.6 seconds with a sigma of 16.4; this mean for women was 37.5 seconds with a sigma of 18.9. For the group 40% of men and 39% of women were quicker with the left while 53% of men and 55% of women were quicker with the right. With the exclusion of one case from the women's data both sexes showed the right feet with an average saving of 2 seconds more than the average left saving. Women averaged 3.5 rubbers in the hole with the left feet and 3.9 with the right while the more expert men averaged 4.6 rubbers in with the left and 4.5 with the right. The aiming ability of both feet was quite similar.

The manipulation or lock test involved several activities in order. Subjects unlocked 3 door locks of the bolt type on a box 9″ by 5″ by 3½″, opened the cover of the box, closed the cover and relocked the three locks. Most of the manipulation was done by the big toe. To open the cover with the left foot and sometimes with the right foot, was very difficult for some cases.

From Tables II and IV the left mean was 72.9 seconds with a sigma of 27.4 while the right mean was 66.2 seconds with a sigma of 22.2 for the entire group of 83 cases. From Tables V and VI 38% of the group were quicker with the left with an average saving of 14 seconds while 59% were quicker with the right foot with an average saving of 20.6 seconds.

Men were quicker than women with both feet with greater differentiation between the two sides. The left mean for men was 69.3

seconds with a sigma of 24.5 while this mean for women was 76.2 seconds with a sigma of 29.1. The right mean for men was 64.2 seconds with a sigma of 20.9 while this mean for women was 68.3 seconds with a sigma of 22.9. In terms of quicker performance 41% of men and 37% of women were quicker with the left while 59% of men and 59% of women were quicker with the right. In terms of average seconds saved men's right feet were quicker than the left by 4.6 seconds while women's right feet excelled the left by 8.2 seconds.

The sixth test was the Wallin pegboard with the six round pegs. The subject picked up the pegs from a board at the side and placed them in the pegboard directly in front of them. The method of holding the pegs was important for success. Pegs could not be gripped tightly enough between the toes to prevent their slipping. Grasping the tips of the pegs under the second and third toes with the foot turned a little for better vision of the holes, proved to be the best method of performance. If a peg slipped up so high between the toes that it could not be used, subjects had a very difficult time in getting rid of it. Toes of the other foot and fingers of both hands would be spread wide in the tension of the effort. If a person felt some ease in performance, pegs were often tapped lightly after they were in position. Vision as well as head movements were important in the task. Most subjects expressed some idea, such as "Can feel better with the right" or "Can aim better with the right." Subjects showed great weariness after this test.

From Tables II and IV the mean performance for the 100 cases was 146.1 seconds for the left with a sigma of 58.8 and 131.6 seconds for the right with a sigma of 45.2. The 38% who were quicker with the left foot had an average saving of 31.4 seconds while the 61% who were quicker with the right foot had an average saving of 43.4 seconds.

In comparing the sexes, both gave similar responses with the right feet but women were distinctly slower with the left. The mean for the left feet of men was 138 seconds with a sigma of 48.9 while this mean for women was 154.6 seconds with a sigma of 66.2. The right mean for men was 131.2 seconds with a sigma of 51.1 and this mean for women was 132.6 seconds with a sigma of 38.9. For

the group 40% of the men and 36% of the women were quicker with the left foot while 58% of men and 64% of women were quicker with the right side. In terms of average seconds saved men's right feet excelled the left by 1 second while women's right feet excelled the left by 23 seconds.

The seventh test was replacing the parts of the Seguin formboard. The board was always placed so the circle appeared in the lower corner next to the foot tested. This meant that the board was turned over for the right foot in which position some of the forms fitted somewhat more tightly. The forms to be placed were put beside the foot to be tested on a level with the formboard in such an order that the larger pieces, namely the circle, hexagon, oval and half circle were placed before the other pieces. This prevented the smaller pieces from being caught in the larger holes and thus producing an occasional increase of time. In perhaps the first 50 cases the experimenter picked up the half circle in such a manner as to favor slightly the left foot since the piece did not need to be turned around. This may have favored slightly the left feet of women since 31 women were in the first 50 cases. The left foot worked in the direction from left to right, as in writing and reading while the right foot had the less practiced direction right to left. These various factors were probably sufficient to change the test from a right differentiation which should have been expected from the fine motor coordinations involved, to a test favoring the left side. This test was given to a different group of students than the others. It had been intended to be given without vision but was too difficult for this.

From Tables II and VIII the mean performance for 90 cases was 75.9 seconds with the left foot with a sigma of 20.9 and 78.5 seconds with the right foot with a sigma of 18.4. The 58% of cases who were quicker with the left foot showed an average saving of 13 seconds and the 40% who were quicker with the right foot had an average saving of 13 seconds also.

In comparing the sexes women showed little difference between the feet but men gave a better performance with the left. The mean for the left feet of men was 71.9 seconds with a sigma of 23.8 and the same mean for women was 80.1 seconds with a sigma of 16.8. The right mean for men was 76.4 seconds with a sigma of 21.1; this

mean for women was 80.5 seconds with a sigma of 14.8. In terms of seconds saved according to Table IX, 64% of men and 51% of women were quicker with the left foot while 33% of men and 47% of women were quicker with the right. The seconds saved averaged for the left 14.9 for men and 10.7 for women and for the right foot 15.1 for men and 10.6 for women.

Of the seven tests given with vision, 5 favored the right foot and 2 the left foot. For all cases 4 means were smaller for the right foot and 3 smaller for the left. Five of the midscores were smaller for the right foot while one was the same for both feet and one was smaller for the left. Sigma was greater for the left foot in 4 tests, the same for both feet in one test and greater for the right on two tests. The percent of cases quicker with the right foot was significantly greater on five of the seven tests.

From the standpoint of sex performance men had 6 of the 7 means smaller for right feet while women had 4 smaller for right feet, one for left feet and two with no difference. Men had 6 midscores smaller on the right side and women had 5. In the case of sigma men showed greater variability with the left side in 6 of the 7 tests while women had greater variability on the left side in 4 tests. Men had more cases quicker with the right side in 6 of the tests and women in 5. If the left feet of men be compared to the left feet of women, men's left means were smaller than women's in 5 of the 7 tests. The means for men's right feet were less than women's in 6 of the 7 tests. Men were more efficient with their feet than women in performance time.

(3) Specific Measures of Feet Without Vision

Three tests were given without vision to another group of 90 students, one rather simple test and two more difficult integrations. To prevent vision of the feet and yet maintain flexibility of body with the smallest possible inhibition, a very large cloth apron 50 by 30 inches with an inner lining of opaque paper was tied about the neck of the person and fastened at the two outer corners about 40 inches from the floor.

The grasping test without vision was designed to be comparable to the pegboard test mentioned above. In a board 12 by 24 inches

which had been raised 5 inches from the floor, were made 6 three-quarter inch holes. These holes were placed in a semicircular formation 8 inches from a center two-inch hole. Back of the two-inch hole along the entire length of the board was a small board 1¼ inches high to prevent the subject from getting off the board. In the six holes were placed six clothespins with the heads sawed off. The grooved openings in the clothespins were placed upward and formed a convenient place for the second toe to fit in as they were picked up. About 2½ inches of the clothespin protruded above the holes. The side of the board with the two-inch hole was placed at a convenient distance from the subject. Subjects did not see the equipment prior to the test but the experimenter carefully touched the foot of the subject to the six clothespins and had them bend their big toes into the central hole. Without much difficulty (only one subject could not pick up the pins) the pins were picked up and dragged across the board until the subject felt the end fall into the hole. The person could hear the pin drop through the hole to the floor. If the pin just dropped on the board, the experimenter replaced this pin in one of the holes. The subject worked until all six pins were dropped into the central hole. Some subjects found the hole with the heel while grasping the pin with the toes, a very effective procedure. The test was very fatiguing since the feet had to be held up from the floor about 8 inches throughout the test. Most subjects requested to see the apparatus since they did not have a very clear idea of what it was like from the performance.

From Tables II and VIII the mean performance for 90 cases was 144.9 with the left foot with a sigma of 64.9 and 140.2 with the right foot with a sigma of 70.3. Of the cases 46% were quicker with the left in terms of seconds saved in performance and 53% with the right. The average difference for the seconds saved with the left was 49.3 seconds according to Table IX and 50.8 seconds with the right.

In comparing the sexes women were quicker with both feet than men with the difference more marked in the right than the left. The mean for the left feet of men was 147.9 seconds with a sigma of 68.0; this mean for women was 141.8 seconds with a sigma of 61.4. The mean for the right feet of men was 145.2 with a sigma of 77.1; this

TABLE VII.

Performance Time in Seconds for Men of the Second Group on Foot and Hand Tests With and Without Vision

No. Subject	FEET								HANDS					
	Vision		No Vision						No Vision		Vision		No Vision	
	—Formboard—		—Grasping—		—Manipulation—		—Pressing—		—Formboard—		—Formboard—		—Grasping—	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1.	94	174	231	253	521	346	38	38	98	103	29	29	64	73
2.	76	73	61	59	89	85	22	34	92	115	28	26	97	55
3.	72	114	135	83	118	119	43	47	77	89	31	44	58	65
4.	53	78	75	155	213	410	30	26	108	92	24	28	75	66
5	70	75	144	114	157	148	26	24	109	109	30	32	117	97
6.	68	65	109	144	150	152	33	48	169	170	30	31	56	105
7	61	69	132	192	675	390	38	41	85	100	28	28	194	129
8	76	92	273	321	237	200	27	31	182	184	37	31	84	76
9.	73	65	173	109	98	135	38	21	69	63	25	33	91	105
10.	73	73	128	80	210	201	30	32	124	117	35	34	56	61
11.	61	72	76	78	161	210	23	21	133	157	26	28	100	110
12.	50	65	171	100	73	60	35	30	269	205	31	31	66	55
13.	69	59	362	170	356	199	46	39	211	148	32	29	100	177
14.	72	67	151	420	115	107	21	37	107	91	27	25	75	70
15.	44	68	164	199	225	129	34	23	160	168	25	27	67	56
16.	58	66	178	157	278	239	26	27	108	102	30	28	93	92
17.	65	90	112	129	411	278	27	42	116	125	33	31	76	90
18.	65	74	93	101	125	93	25	28	151	139	31	28	220	165
19.	78	85	146	172	194	143	19	17	278	371	30	34	58	66
20.	51	58	79	55	182	114	28	24	73	87	27	30	141	85

No. Subject	20.	51	58	79	55	182	114	28	24	73	87	27	30	141	83

No. Subject	FEET								HANDS					
	Vision		No Vision						No Vision		Vision		No Vision	
	—Formboard—		—Grasping—		Manipu-lation		Pressing—		—Formboard—		—Formboard—		—Grasping—	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R
21.	110	94	238	117	439	333	29	18	100	81	35	25	66	61
22.	144	89	258	198	226	161	36	28	260	298	40	33	185	197
23.	60	66	84	151	318	375	36	28	250	255	27	30	125	69
24.	110	114	255	277	183	203	25	24	230	226	35	39	76	70
25.	84	61	127	71	300	138	25	43	79	68	23	25	49	47
26	60	61	53	110	140	192	24	32	67	86	28	23	54	55
27.	65	55	229	178	286	255	31	29	71	61	28	25	68	73
28.	54	68	108	156	145	230	35	40	175	222	28	32	71	44
29.	63	56	84	76	234	150	19	24	155	103	28	32	66	66
30.	52	63	118	140	133	161	20	17	138	108	25	24	70	49
31.	66	82	170	106	187	273	33	41	100	82	33	32	100	74
32.	54	66	76	48	146	125	24	22	126	140	32	28	76	54
33.	68	73	135	107	289	227	25	30	206	199	32	32	246	203
34.	54	60	100	73	90	108	14	15	75	63	28	25	41	42
35.	74	86	141	72	207	184	38	28	250	138	30	31	155	128
36.	69	89	136	110	135	148	24	42	376	531	29	36	71	82
37.	69	95	149	113	196	105	43	49	151	200	31	32	76	60
38.	60	66	121	144	160	143	18	23	213	149	30	31	68	73
39.	55	56	141	141	182	196	48	26	130	144	29	30	51	64
40.	58	67	106	80	67	100	34	35	220	268	29	31	65	65
41.	81	78	66	86	150	132	33	29	116	122	26	28	57	53
42.	66	65	201	238	471	409	26	44	139	123	32	31	52	64
43.	61	54	66	99	301	148	23	25	119	146	32	31	76	74
44.	171	99	269	206	426	348	31	38	276	238	35	36	58	87
45.	97	94	235	349	314	334	46	40	558	800	31	39	53	45
Average	71.9	76.4	147.9	145.2	229.2	198.6	29.9	31.1	162.2	168.6	29.9	30.4	88.1	82.2

TABLE VIII.

Performance Time in Seconds for Women of the Second Group on Foot and Hand Tests With and Without Vision

No. Subject	FEET								HANDS					
	Vision		No Vision						No Vision		Vision		No Vision	
	—Formboard—		—Grasping—		—Manipulation—		—Pressing—		—Formboard—		—Formboard—		—Grasping—	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R
46.	84	102	81	127	95	76	37	28	90	88	35	36	35	43
47.	125	117	311	96	313	139	45	50	148	98	31	27	40	65
48.	99	102	138	124	214	146	36	37	138	119	38	38	63	67
49.	91	98	153	435	201	126	28	34	167	167	33	33	55	54
50.	69	62	97	119	236	196	34	46	159	142	34	40	100	84
51.	79	68	90	95	249	145	37	31	472	273	32	34	60	110
52.	61	83	72	88	90	108	33	34	149	126	38	39	64	105
53.	71	68	109	170	263	124	24	34	275	207	33	34	60	42
54.	100	95	188	170	248	180	38	34	128	177	31	43	77	78
55.	50	76	118	98	225	88	34	27	114	246	25	32	60	65
56.	102	94	158	125	158	166	30	30	109	104	33	35	50	51
57.	57	75	127	137	114	117	40	43	100	169	30	37	85	77
58.	72	91	100	155	158	138	34	42	163	120	37	41	152	122
59.	73	75	90	84	132	133	36	33	119	115	30	30	46	56
60.	86	90	157	120	253	131	49	47	147	134	40	45	90	125
61.	75	78	81	124	279	299	39	23	91	117	36	34	92	88
62.	81	89	131	102	188	104	27	18	263	193	32	29	88	41
63.	75	77	100	76	206	194	33	59	152	138	30	29	79	87
64.	73	68	186	90	155	252	46	58	262	205	34	30	81	65
65.	78	88	95	71	118	87	24	48	192	210	32	35	74	64
66.	77	98	170	253	297	174	25	29	455	303	33	35	57	45
67.	85	90	119	117	102	106	31	37	329	274	41	35	106	120

66.	77	98	170	253	297	174	25	29	455	303	33	35	57	45
67.	85	90	119	117	102	106	31	37	329	274	41	35	106	120

No. Subject	FEET								HANDS					
	Vision		No Vision						No Vision		Vision		No Vision	
	—Formboard—		—Grasping—		Manipu-lation		Pressing—		—Formboard—		—Formboard—		—Grasping—	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R
68.	78	75	101	140	208	165	22	27	205	195	30	29	75	66
69.	61	65	136	181	98	162	32	27	123	99	25	31	72	61
70.	89	112	98	162	151	339	19	30	198	188	24	28	73	84
71.	112	86	174	126	332	139	54	43	402	176	36	34	92	70
72.	73	73	268	120	152	119	24	20	129	102	31	36	73	70
73.	74	72	70	71	193	265	22	18	239	168	28	28	65	73
74.	107	100	154	134	182	173	31	28	159	256	40	44	54	96
75.	52	74	93	111	206	221	27	30	190	269	36	35	98	109
76.	78	96	108	78	146	103	23	20	93	77	30	31	104	71
77.	94	81	74	94	305	173	36	25	250	362	33	33	107	132
78.	86	82	83	141	486	285	26	37	138	125	30	33	59	82
79.	69	66	149	112	235	229	34	25	138	112	32	26	67	66
80.	92	65	137	126	167	99	26	32	58	92	25	25	46	55
81.	98	97	127	117	259	297	40	33	277	241	32	30	65	79
82.	98	72	274	157	148	212	48	39	96	93	31	32	54	81
83.	63	64	156	150	245	134	35	24	72	82	30	30	70	75
84.	76	80	154	194	163	141	44	33	96	84	31	28	73	74
85.	81	67	274	200	212	133	25	20	178	132	36	28	46	49
86.	66	61	154	132	176	121	36	34	195	237	32	36	87	104
87.	110	70	156	192	164	148	66	36	365	282	33	31	58	59
88.	72	73	314	203	285	166	30	34	139	253	29	30	65	64
89.	56	51	180	113	171	178	24	24	310	256	29	28	—	—
90.	55	60	77	109	153	126	21	25	66	64	26	29	34	44
Average	80.1	80.5	141.8	135.2	202.9	163.4	33.4	33.	185.2	170.4	32.3	33.	71.6	75.4
Average all	75.9	78.5	144.9	140.2	216.0	181.0	31.7	32.1	173.7	169.5	31.0	31.7	79.9	78.8

TABLE IX.

Comparison of Left and Right Sides of Subjects of theSecond Group in Terms of Seconds Saved with the Preferred Member in Paired Trials in Performance With and Without Vision

TESTS WITH FEET

	Vision			No Vision								
	—Formboard—			—Grasping—			Manipu-lation			—Pressing—		
	R	L	E*	R	L	E	R	L	E	R	L	E
No. cases of men	15	29	1	23	21	1	29	16	0	20	24	1
Average saving	15.1	14.9	..	50.7	49.8	..	72.0	44.5	..	6.6	7.6	..
No. cases of women	21	23	1	25	20	0	31	14	0	23	20	2
Average saving	10.6	10.7	..	50.9	48.8	..	76.5	42.8	..	7.9	8.1	..
Total cases	36	52	2	48	41	1	60	30	0	43	44	3
Average saving	12.5	13.0	..	50.8	49.3	..	74.4	43.7	..	7.3	7.8	..

TESTS WITH HANDS

	No Vision			Vision			No Vision		
	—Formboard—			—Formboard—			—Grasping—		
	R	L	E	R	L	E	R	L	E
No. cases of men	21	23	1	18	23	4	25	18	2
Average saving	27.8	37.5	..	3.2	3.5	..	21.9	15.7	..
No. cases of women	32	12	1	15	23	7	17	27	0
Average saving	14.1	65.2	..	3.1	3.7	..	14.2	15.2	..
Total cases	53	35	2	33	46	11	42	45	2
Average saving	19.5	47.2	..	3.1	3.6	..	18.8	15.4	..

* Equal

mean for women was 135.2 with a sigma of 62.9. In terms of seconds saved 44% of the women and 47% of the men were quicker with the left; 56% of women and 51% of men were quicker with the right. The average for the seconds saved for the left was 48.8 seconds for women and 49.8 seconds for men; for the right the average was 50.9 for women and 50.7 for men.

The equipment for the manipulation test without vision consisted of a 12-inch serving tray with an inverted wooden bowl screwed fast to the center of the tray. The bowl was 6 inches wide and 2 inches deep with a three-quarter inch hole bored in the bottom of it. Subjects had to lift with the toes 10 one-half inch marbles from the bottom of the tray to the inverted bottom of the bowl and place them in the hole. This task required considerable integration. Although subjects tried to locate the hole with the end of the big toe and then place the marbles into it, this procedure did not help very much. The best method was to pick up the marble, hold it lightly under the toes and then roll it about on the bottom of the bowl. In this difficult integration the right foot proved to be distinctly superior.

From Tables II and VIII the mean performance for 90 cases was 216.0 seconds with the left with a sigma of 104.2 and 181.0 seconds with the right with a sigma of 80.5. Of the cases 33% were quicker with the left and 67% with the right in terms of seconds saved. The average difference in seconds saved was 43.7 seconds for the left and 74.4 with the right.

In comparing the sexes women were quicker than men with both feet with the difference much greater for the right as in the preceding test. Variability of men was greatly increased. The mean for the left feet of men was 229.2 seconds with a sigma of 127.3; this mean for women was 202.9 seconds with a sigma of 74.5. The mean for the right feet of men was 198.6 seconds with a sigma of 93.3; this mean for women was 163.4 seconds with a sigma of 60.9. The left foot functioned quicker for 36% of the men and 31% of women while 64% of men and 69% of women were quicker with the right foot. In terms of seconds saved with the left, men averaged 44.5 and women 42.8; with the right, men averaged 72.0 and women 76.5 seconds.

TABLE X.

Lateral Preference for Hands on Gross Motor Tests

Test	Women						Men						All Cases					
	Number of Cases			Per Cent of Cases			Number of Cases			Per Cent of Cases			Number of Cases			Per Cent of Cases		
	L	E*	R	L	E	R	L	E	R	L	E	R	L	E	R	L	E	R
1. Hand in scissors	1	..	12	8	..	92	2	..	27	7	..	93	3	..	39	7	..	93
2. Hand on trigger	1	..	18	5	..	95	4	..	29	12	..	88	5	..	47	10	..	90
3. Hand holding eyeglass	3	..	14	18	..	82	4	..	18	18	..	82	7	..	32	18	..	82
4. Hand holding thread	8	..	23	26	..	74	4	..	30	12	..	88	12	..	53	18	..	82
5. Hand on end of shovel	10	..	40	20	..	80	11	1	38	22	2	76	21	1	78	21	1	79
6. First arm into coat	20	1	22	47	2	51	9	..	36	20	..	80	29	1	58	33	1	65
7. Hand on end of broom	20	..	30	40	..	60	16	..	34	32	..	68	36	..	64	36	..	64
8. First hand in glove	21	1	15	57	3	41	26	1	16	60	3	37	47	2	31	59	2	39
9. First hand out of glove	7	1	5	54	8	38	15	..	9	63	..	37	22	1	14	59	3	38
10. First arm out of coat	29	..	14	67	..	33	36	..	9	80	..	20	65	..	23	74	..	26
Average for tests 1-7				23		76				18		82				20		79

* Either hand.

The pressing test was a simple one involving pressing or manipulating 100 ball bearings through small holes in an 8½-inch colendar fastened to a 10½-inch pietin in a slightly tilted fashion. On the lower third of the colendar on the side tilted toward the subject, were 34 holes in three rows which just permitted the ball bearings to pass through. Subjects used a pawing motion of the foot in this very simple task in which lack of vision was relatively unimportant.

From Tables II and VIII the mean performance for 89 cases was 31.7 seconds for the left foot with a sigma of 8.9 and 32.1 seconds for the right foot with a sigma of 9.5. The average difference for seconds saved in Table IX was practically the same for both feet. Of all the subjects 49% were quicker with the left foot and 48% with the right.

In comparing the sexes men were slightly quicker than women with both feet with the difference somewhat greater in the left. The mean for the left feet of men was 29.9 seconds with a sigma of 8.6; this mean for women was 33.4 seconds with a sigma of 9.3. The mean for the right of men was 31.1 seconds with a sigma of 9.5; this mean for women was 33.0 seconds with a sigma of 9.4. In terms of seconds saved 53% of men and 44% of women were quicker with the left while 44% of men and 51% of women were quicker with the right. With the left foot men averaged 7.6 seconds saved and women 8.1; with the right foot men averaged 6.6 and women 7.9 seconds.

The lack of vision was not important in a simple movement, such as the one used in the pressing test. In the more complex movements without vision there was a significant increase in time of performance and variability of response. In a very difficult test, such as the manipulation of marbles into the inverted bowl the difference between sides was greatly exaggerated. In this test the difference between the left and right mean for the group was more than double that of the pegboard test. The greater right preference was shown also by a significantly greater percent of cases quicker with the right foot. The difference between the percent of cases quicker with the right than with the left was 23 in the pegboard test and 34 in the inverted bowl without vision.

An interesting sex difference appeared in response to the situation. In most of the former foot tests with vision men had been quicker than women with both feet but in the more difficult tests without

vision women's feet were quicker than men's. In the grasping test women's left feet were 6 seconds quicker than men's and their right feet 10 seconds quicker. In the manipulation test women's left feet were 26 seconds quicker than men's and their right feet 35 seconds quicker than men's. Similarly sigma for women's feet was considerably less than sigma for men in the case of both feet on the two complex tests without vision. Either women were more patient and less thwarted by the situation or they had a better sense of orientation to position without vision.

6. *Description of Results of Hand Tests.*

(1) Gross Tests of Laterality

Although the purpose of this investigation was primarily a study of laterality in feet, some hand tests were given to the same group of students for the purpose of comparison with the foot tests. Records were kept for 10 tests of gross motor movements although the number of cases vary for these. Sometimes the test period was too short to complete all the tests and these were omitted rather than any of the foot tests. As Table X shows, 60% or more of the cases preferred the right hand in 7 of the 10 tests. In 3 of the tests the left was favored because the task represented the least work. In 59% of cases the left hand was put into the glove first with the right hand free to do the pulling. In 59% of cases the left hand was taken out of the glove first because the stronger right was needed to pull off the fingers of the glove. In 74% of the cases the left arm was taken out of the coat first, thus leaving the stronger right arm to hold and hang up the coat.

From the standpoint of sex differences the percent of cases favoring the right hand for the two sexes was very similar. In the pair of measures, the first arm in and the first arm out of a coat, there was a noticeable sex difference. Women were equally divided in their preference for the first arm into a coat while men favored the right in 80% of the cases. Women took out the left arm in 67% of cases and men in 80% of cases. Men's overcoats usually weigh much more than women's; therefore they more often took out the left arm so the right might support the weight of the coat.

In comparing the gross measures of laterality in feet with those in hands, a clearer preference for the right hand was found than for the right foot. For all cases the average preference for the right hand in 7 tests was 79% and for the right foot in 10 tests was 59%. For all cases the average preference for the left hand was 20% and for the left foot 41%. The results seemed to indicate that custom and practice determine a greater right preference in hands than in feet.

In comparing sex differences on gross tests Tables I and X show that men preferred the left hand in 18% of cases and the left foot in 46%. They preferred the right hand in 82% of cases and the right foot in 52%. Women preferred the left hand in 23% of cases and the left foot in 34%. They preferred the right hand in 76% of cases and the right foot in 65%. Handedness and footedness in women tended to be more similar than in the case of men.

(2) Specific Measures of Hands With Vision

In the first test a time record was kept for tapping 300 taps with the thumb upon a telegraph key attached to an electric counter. The little finger rested upon the side of the apparatus so that the movement involved the thumb and wrist rather than the whole arm. The apparatus and method was the same used in the foot tapping test already discussed. The mean performance for 100 cases was 67.6 seconds with the left hand with a sigma of 13.8 and 60.5 seconds with the right hand with a sigma of 14.2. Of the cases 17% were quicker with the left hand and 81% with the right. The average difference for the seconds saved with the left was 5.8 and with the right 9.9 seconds. Tables II and IX should be consulted.

In comparing the sexes the men were quicker with both hands than the women. The mean for the left hand of men was 61.7 seconds with a sigma of 11.5; this mean for women was 74.7 seconds with a sigma of 12.7. The mean for the right hand of men was 54.5 with a sigma of 12.9; this mean for women was 67.6 seconds with a sigma of 12.5. In terms of seconds saved by the preferred hand, 20% of men and 14% of women were quicker with the left hand while 80% of men and 82% of women were quicker with the right hand. The average for the seconds saved for the left hand of men

TABLE XI.

The Number and Per Cent of Cases with a Quicker Performance with the Left and Right Hands on Various Tests

Test	Left Hand						Right Hand					
	Men		Women		Total		Men		Women		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Vision												
1. Tapping	10	20	7	14	17	17	40	80	41	82	81	81
2. Seguin Formboard	23	51	23	51	46	51	18	40	15	33	33	24
No Vision						51	25	56	17	39	42	47
1. Grasping transfer	18	40	27	61	45							
2. Seguin Formboard	23	51	12	27	35	39	21	47	32	71	53	59
Average of all tests		41		38		40		56		56		53
Average without S. Formboard		30		38		34		68		61		64

was 7.5 seconds and for women 3.3 seconds. The average for the seconds saved for the right hand of men was 10.5 and for women 9.2 seconds.

A comparison of the tapping test of hands and feet based on Tables II, V, XI showed several interesting facts. Right foot mean performance was quicker than the left by nearly 6 seconds while right hand mean performance was quicker than the left by nearly 7 seconds. Both right feet and hands showed very slightly more variability than the corresponding left parts. In comparing the percent of cases quicker with a given side, there were 31% more cases quicker with the right foot than the left foot while there were 64% more cases quicker with the right hand than the left. Practice factors apparently established more difference between the hands than the feet in this test.

A similar comparison of the sexes showed that the mean for men's right feet were shorter than the left by 5.8 seconds while women's right mean was shorter than the left by 6.6 seconds. The difference between the means for the right and left hands was 7 seconds for both sexes. Women's hands and feet showed practically no difference in variability between the sides. Men's left feet were more variable than their right feet but their right hands were slightly more variable than their left ones. In comparing the percent of cases preferring the left or right side, there were 48% more women preferring the right than the left feet and 68% more preferring right hands than left hands. Similarly there were 14% more men quicker with the right foot than the left while 60% more were quicker with the right hand than the left. Men showed similar differences between the two sides as women in the case of the hands but training had made men more efficient with left feet.

The second test with vision was the Seguin formboard with the testing technique the same as with the feet. The mean performance for 90 cases according to Tables II and VIII was 31.0 seconds with the left and 31.7 seconds with the right with sigma practically the same for both. Of the cases according to Table XI, 51% were quicker with the left hand and 24% with the right. No difference between the hands was shown in 24% of cases. The average difference for the seconds saved by the preferred side according to Table IX was 3.6 seconds for the left and 3.1 seconds for the right.

Tables II, VII and VIII showed the left mean for men was 29.9 seconds with a sigma of 5.4; this mean for women was 32.3 seconds with a sigma of 4.8. Men's right mean was 30.4 seconds with a sigma of 5.3; this mean for women was 33.0 with a sigma of 5.9. In terms of seconds saved by the preferred hand, 51% of men and 51% of women were quicker with the left hand while 40% of men and 33% of women were quicker with the right hand. The average for the seconds saved with the left hand was 3.5 for men and 3.7 for women while the average for the right hand was 3.2 for men and 3.1 for women.

A comparison of this test with feet and with hands based on Table II showed that the test situation favored consistently the left side. Left feet showed in mean performance greater advantage over right feet than left hands over right hands. Left feet were more variable than right feet while left and right hands showed about the same variability. In comparing the percent of those preferring left or right feet, there were 18% more who favored left feet over right feet; similarly there were 27% more who favored left hands over right hands. The sexes showed no difference between paired results of the hands but the left mean for men's feet were 4.5 seconds quicker than the right while the left mean for women's feet was only 0.4 less than the right.

(3) Specific Measures of Hands Without Vision

The first test was to transfer 100 ball bearings from one dish 5½ inches in diameter to another dish of the same size 12 inches away with the hands moving in a horizontal line. Records of time and trips were kept. This test was similar to the foot test of grasping and carrying marbles from one dish to another. The same dishes were used in both tests. The mean performance for 89 cases was 79.9 seconds with the left hand with a sigma of 37.3 and 78.8 seconds with the right with a sigma of 31.8. Of the cases 51% were quicker with the left and 47% with the right. The average difference for the seconds saved with the left was 15.4 and with the right 18.8.

In comparing the sexes, the women gave a swifter performance than men with both hands. The mean for the left hand of men was 88.1 with a sigma of 46.1; this mean for women was 71.6 with a

sigma of 22.5. The mean for the right hand of men was 82.2 with a sigma of 37.9; this mean for women was 75.4 with a sigma of 23.7. In terms of seconds saved by the preferred hand 40% of men and 61% of women were quicker with the left hand while 56% of men and 39% of women were quicker with the right hand. The average for the seconds saved for the left hand of men was 15.7 and for women 15.2. This average for the right hand of men was 21.9 and for women 14.2.

A comparison of this test with the grasping and carrying test with feet based on Tables II showed that time for the task was slightly less for left feet than right feet while the time for hands was slightly less for right than left. Right feet were somewhat more variable than left while left hands were still more variable than right ones.

Table II showed an interesting sex difference, namely that the women consistently favored the left side and men the right side. Right means for men's feet were 6.6 seconds less than left ones; right means for their hands were 5.9 seconds less than left ones. Both right feet and right hands were less variable than left ones. Strangely enough women showed a complete reversal of efficiency of sides from that of men in this test. Left means for women's feet were 9.5 seconds less than right ones; left means for their hands were 3.8 seconds less than right ones. The left hand and the left foot were less variable than the corresponding right member with the difference greater between feet.

The number of trips required for this test threw some light upon this difference in difficulty. The 49% of men who made less trips with the right foot made on an average of 2.5 trips less while the 37% of men who made less trips with the left foot, made on an average of 2.8 trips less. The 22% of women who made less trips with the right foot, averaged 1.9 trips less while the 54% who made less trips with the left foot averaged 2.6 trips less. The 46% of men who made less trips with the right hand averaged 6 trips less while the 44% who made less trips with the left hand averaged 5.6 trips less. The 28% of women who had less trips with the right hand averaged 5.5 less trips while the 61% who made less trips with the left hand averaged 4.1 less trips. Usually the more relaxed hand or foot carried more marbles.

The second test without vision was the Seguin formboard. The board was placed so the circle was nearest the hand working. This necessitated a reversal of the board. With vision no one remarked upon the change. When subjects could not see the board, most of them in the second trial called attention to the reversal. The mean performance for 90 cases with the left hand was 173.7 seconds and with the right 169.5 seconds. Sigma was about the same for both hands. Of the cases 39% were quicker with the left hand and 59% with the right hand. The average difference for the seconds saved was 47.2 with the left and 19.5 with the right.

In comparing the sexes the mean for the left hand of men was 162.2 seconds with a sigma of 92.5; this mean for women was 185.2 with a sigma of 99.7. The mean for the right hand of men was 168.6 with a sigma of 129.8; this mean for women was 170.4 with a sigma of 72.9. In terms of seconds saved by the preferred hand, 51% of men and 27% of women were quicker with the left hand while 47% of men and 71% of women were quicker with the right hand. The average of seconds saved for the left hand of men was 37.5 and for women was 65.2. This average for the right hand of men was 27.8 and for women 14.1.

A comparison of means on the Seguin formboard with and without vision showed that lack of vision significantly increased the time. The left hand required 143 more seconds without vision and the right 138 seconds more. Perhaps the most significant difference was the increased preference for the right hand in this test which has already been noticed to have been easier with the left member. With vision 51% of cases were quicker with the left hand and without vision only 39%. With vision 24% were quicker with the right hand and without vision 59%. This change in preference occurred mostly in women. Both with and without vision 51% of men were quicker with the left hand. With vision 51% of women were quicker with the left but without vision only 27% were quicker with the left. From Table IX however, the average gain for the groups preferring the left hand was 10 more than the right group for men and 51 more for the women. Without vision subjects, especially women, tended to be more sure with the right hand.

7. *Description and Results of Ear and Eye Tests*

1. Ear Tests

Equipment did not permit a very accurate check upon laterality of eyes and ears of subjects. In the first test of ear dominance the subject placed the entire head inside of a large pasteboard cone, 4 feet long, 15 inches in diameter at large end and 4 inches at the small end. At the small end the experimenter held a stop watch that was not running. The subject was asked to listen to the watch which of course could not be heard. If the subject did not turn the head naturally to indicate the preferred ear in the situation, he was merely urged to listen more carefully. This urging brought the desired response of turning one or the other ear toward the experimenter. Of the cases 43% turned the left ear and 57% the right ear. In the second test a small box with a stop watch in it was held directly in front of the nose of the subject. The subject was directed thus, "Put your ear upon the box to see if you can hear the stop watch." In this test 48% of the cases turned the left ear to the box and 51% the right ear. These two situations were selected because they seemed to be less apt to bring the response habituated by use of the telephone. The average for the two responses was 45.5% preference for the left ear and 54.5% for the right ear. Sexes responded similarly.

2. Eye Tests

The subjects were first asked to look into a microscope. Of the cases 38% preferred the left and 57% the right eye. The usual cone test was administered with 34% preferring the left eye and 66% the right eye. In the peephole test the pasteboard with the small opening in it was held by the experimenter directly in front of the subject who was directed to look through the hole toward an object beyond. Of the cases 34% preferred the left eye and 65% the right eye. In the last test the subject was asked to wink at the experimenter, 30% used the left eye and 61% the right eye. It was rather surprising that many cases could wink with only one eye. More cases of men were able to use both eyes for the activity than of women, an achievement usually voluntarily mentioned with some pride. An average for the

TABLE XII.

Lateral Preference for Eyes and Ears

Test	Women						Men						All Cases					
	Number of Cases			Per Cent of Cases			Number of Cases			Per Cent of Cases			Number of Cases			Per Cent of Cases		
	L	E*	R	L	E	R	L	E	R	L	E	R	L	E	R	L	E	R
Ear tests																		
1. Tube test	21	..	29	42	..	58	20	..	26	43	..	57	41	..	55	43	..	57
2. Box test	21	..	24	47	..	53	21	1	22	48	2	50	42	1	46	48	1	51
Average				44		55				45	..	53				45		54
Eye tests																		
1. Microscope	33	2	56	36	2	62	36	7	47	40	8	52	69	9	103	38	5	57
2. Cone	16	..	33	33	..	67	17	..	31	35	..	65	33	..	64	34	..	66
3. Peephole	30	..	54	36	..	64	20	1	42	32	2	66	50	1	96	34	1	65
4. Winking	14	2	28	32	4	64	12	6	26	27	14	59	26	8	54	30	9	61
Average				34		64				34		61				34		63

* Either

four eye tests showed the group to have 34% preference for the left eye and 63% preference for the right eye.

In comparing the results of eye and ear tests, results showed a much stronger preference for the right eye than for the right ear. The sexes gave similar responses with ears but women showed slightly greater preferenc for right eyes than men. Table XII gives additional data.

8. *Individual Analysis of Data*

(1) First Group of Subjects

This analysis has been worked out in terms of units of leftness and rightness. A unit was considered as 10 seconds difference in performance time, for example a difference of 1-10 seconds was called 1 unit, a difference of 11 to 20 seconds was called 2 units and so on. Three bases of comparison were used, namely the difference in number of shortest trials of the given test series, the paired differences between the two sides in performance time and the difference in the two sides in rate of decrease of performance time from the first to last repetition. On each of the 6-foot tests used with the students of the first group, the shortest trial of the six repetitions was recorded for the quicker foot. Usually the difference between the shortest trials for the left and for the right was less than 10 seconds; hence each shortest trial was counted as 1 unit for the given side. In Table XIII the first subject had 4 shortest trials on the left and 2 on the right side; this gave a difference of 2 trials or 2 units for the left side. In the paired difference column of the same table, the difference totals of Tables III and IV were changed into units and recorded for the given side. Thus the first subject showed a difference total of 45 seconds quicker performance time for the left side or 5 units of leftness. In the third column of Table XIII the difference in rate of decrease in performance time was recorded. The difference between the second and third repetition for the same foot was recorded as seconds of increase or decrease on each test. The second subject showed on the group of tests 47 seconds of decrease and 3 seconds of increase with the left foot and with the right foot he showed 10 seconds of decrease and 9 seconds of increase. The seconds of increase were deducted from

TABLE XIII.

Individual Analysis of Data for Men of First Group on Motor Tests in Terms of Units of Difference in Leftness and Rightness

No.	Feet								Hands		Eyes			
	Shortest —Trial—		Paired —Difference—		Rate of —Decrease—		Difference —Total—		Difference —Total—		—Microscope—		—Cone Test—	
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1.	2	–	5	–	4	–	11	–	–	2	—	—	—	—
2.	–	2	2	–	5	–	5	–	–	2	—	—	—	—
3.	6	–	2	–	–	8	0	0	2	–	L	—	L	—
4.	–	2	–	11	3	–	–	10	–	2	—	R	—	R
5.	–	1	–	4	–	2	–	7	–	2	L	—	L	—
6.	–	3	–	26	7	–	–	22	–	2	—	R	—	R
7.	–	3	–	8	8	–	–	3	–	2	L	—	L	—
8.	–	2	4	–	–	14	–	12	–	2	L	—	—	R
9.	–	1	–	4	–	1	–	6	–	3	—	R	—	R
10	–	5	–	5	9	–	–	1	–	3	—	R	—	R
11.	1	–	4	–	2	–	7	–	2	–	L	—	L	—
12.	–	2	–	4	9	–	3	–	–	2	—	R	—	R
13.	–	4	–	27	–	1	–	32	–	3	L	—	—	R
14.	–	1	–	4	3	–	–	2	–	3	—	R	—	R
15.	–	4	–	7	3	–	–	8	–	3	—	R	—	R
16.	–	2	2	–	7	–	7	–	–	4	L	—	L	—
17.	–	3	–	9	1	–	–	11	–	2	—	R	—	R
18.	4	–	6	–	4	–	14	–	2	–	—	R	—	R
19.	–	3	–	18	4	–	–	17	–	2	L	—	L	—
20.	–	6	–	7	1	–	–	12	–	2	either		—	R
21.	–	1	–	4	–	3	–	8	–	3	L	—	—	R
22.	0	0	–	4	5	–	1	–	2	–	L	—	L	—
23.	1	–	–	3	7	–	5	–	–	2	L	—	L	—
24.	–	1	1	–	–	9	–	9	–	2	L	—	L	—
25.	–	2	–	10	–	14	–	26	–	2	—	R	—	R

No.	Feet								Hands		Eyes			
	Shortest —Trial—		Paired —Difference—		Rate of —Decrease—		Difference —Total—		Difference —Total—		—Microscope—		—Cone Test—	
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R
26.	0	0	5	–	3	–	8	–	–	3	—	R	—	R
27.	–	2	5	–	–	13	–	10	–	2	—	R	L	—
28.	3	–	19	–	–	16	6	–	–	3	—	R	—	R
29.	–	2	–	4	2	–	–	4	0	0	L	—	L	—
30.	–	2	–	3	3	–	–	2	–	2	—	R	—	R
31.	–	1	–	2	3	–	0	0	–	3	—	R	—	R
32.	–	2	–	6	9	–	1	–	2	–	L	—	L	—
33.	–	4	–	13	5	–	–	12	–	2	—	R	—	R
34.	–	6	–	11	2	–	–	15	–	3	L	—	L	—
35.	2	–	–	2	5	–	5	–	–	3	—	R	—	R
36.	–	1	–	3	–	1	–	5	–	4	L	—	L	—
37.	1	–	–	2	–	3	–	4	–	3	—	R	—	R
38.	–	4	1	–	–	1	–	4	–	3	—	R	—	R
39.	–	5	–	8	9	–	–	4	–	2	L	—	—	R
40.	2	–	–	2	–	1	–	1	–	3	—	R	—	R
41.	–	2	–	6	–	9	–	17	1	–	—	R	—	R
42.	–	3	–	8	8	–	–	3	–	2	—	R	—	R
43.	–	2	7	–	7	–	12	–	0	0	—	R	—	R
44.	2	–	2	–	–	6	–	2	–	4	—	R	—	R
45.	–	2	2	–	–	10	–	10	–	3	L	—	L	—
46.	–	4	–	2	2	–	–	4	–	1	—	R	—	R
47.	0	0	6	–	–	6	0	0	4	–	L	—	L	—
48.	–	4	–	9	13	–	0	0	–	3	—	R	—	R
49.	1	–	4	–	–	1	4	–	2	–	L	—	L	—
50.	2	–	–	2	0	0	0	0	–	2	—	R	—	R
Average	2.3	2.7	4.5	7.2	5.1	6.3	6.4	9.1	2.1	2.5				

TABLE XIV.

Individual Analysis of Data for Women of First Group on Motor Tests in Terms of Units of Difference in Leftness and Rightness

No.	Feet								Hands		Eyes			
	Shortest —Trial—		Paired —Difference—		Rate of —Decrease—		Difference —Total—		Difference —Total—		—Microscope—		—Cone Test—	
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R
51.	–	6	–	8	4	–	–	10	–	3	—	R	—	R
52.	–	1	–	4	–	2	–	7	–	2	—	R	—	R
53.	0	0	–	10	3	–	–	7	–	2	—	R	—	R
54.	0	0	8	–	–	10	–	2	–	1	L	—	L	—
55.	–	2	–	3	2	–	–	3	–	2	—	R	—	R
56.	–	3	–	8	15	–	4	–	–	2	—	R	—	R
57.	–	2	–	9	–	3	–	14	–	3	—	R	—	R
58.	–	2	1	–	–	1	–	2	2	–	—	R	L	—
59.	–	2	–	4	–	1	–	7	–	3	L	—	L	—
60.	–	1	1	–	2	–	2	–	–	2	—	R	—	R
61.	3	–	36	–	12	–	51	–	–	3	—	R	—	R
62.	–	6	–	9	8	–	–	7	1	–	—	R	—	R
63.	–	1	–	5	2	–	–	4	2	–	—	R	—	R
64.	0	0	–	20	15	–	–	5	–	3	—	R	—	R
65.	2	–	–	6	4	–	0	0	–	4	L	—	L	—
66.	0	0	–	4	2	–	–	2	2	–	L	—	L	—
67.	0	0	4	–	–	2	2	–	–	4	—	R	—	R
68.	2	–	4	–	18	–	24	–	–	2	L	—	L	—
69.	–	2	–	9	–	7	–	18	–	2	L	—	L	—
70.	2	–	–	3	6	–	5	–	–	2	—	R	—	R
71.	–	4	–	8	–	7	–	19	–	1	—	R	—	R
72.	0	0	–	10	15	–	5	–	–	3	L	—	L	—
73.	–	5	–	19	2	–	–	22	2	–	—	R	—	R
74.	–	2	–	7	4	–	–	5	–	3	L	—	L	—
75.	2	–	4	–	–	4	2	–	–	2	L	—	L	—

No.	Feet								Hands		Eyes			
	Shortest —Trial—		Paired —Difference—		Rate of —Decrease—		Difference —Total—		Difference —Total—		—Microscope—		—Cone Test—	
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R
73.	–	5	–	19	2	–	–	22	2	–	—	R	—	R
74.	–	2	–	7	4	–	–	5	–	3	L	—	L	—
75.	2	–	4	–	–	4	2	–	–	2	L	—	L	—
76.	–	4	–	24	4	–	–	24	–	3	either		—	R
77.	2	–	–	3	1	–	0	0	–	2	—	R	—	R
78.	0	0	–	11	2	–	–	9	–	3	L	—	L	—
79.	–	3	–	11	–	5	–	19	–	3	—	R	—	R
80.	0	0	2	–	–	2	0	0	–	1	—	R	—	R
81.	–	4	–	14	1	–	–	17	2	–	L	—	L	—
82.	–	3	–	7	3	–	–	7	–	2	L	—	L	—
83.	–	2	2	–	8	–	8	–	–	2	—	R	—	R
84.	4	–	13	–	–	17	0	0	–	2	L	—	L	—
85.	2	–	3	–	–	9	–	4	–	1	—	R	—	R
86.	–	5	–	21	6	–	–	20	–	3	—	R	—	R
87.	–	1	6	–	–	6	–	1	–	3	—	R	—	R
88.	–	1	5	–	7	–	11	–	0	0	L	—	—	R
89.	2	–	4	–	1	–	7	–	–	1	L	—	L	—
90.	1	–	3	–	–	3	1	–	–	3	—	R	—	R
91.	1	–	–	14	12	–	–	1	–	2	—	R	—	R
92.	1	–	–	5	4	–	0	0	2	–	—	R	—	R
93.	–	2	–	3	19	–	14	–	–	2	—	R	—	R
94.	–	3	2	–	2	–	1	–	–	1	L	—	—	R
95.	–	2	–	2	23	–	19	–	–	2	—	R	—	R
96.	–	2	3	–	4	–	5	–	–	2	—	R	—	R
97.	2	–	–	2	2	–	2	–	–	2	—	R	—	R
98.	–	2	–	5	–	3	–	10	1	–	—	R	—	R
99.	1	–	5	–	1	–	7	–	–	3	L	—	—	R
100.	0	0	10	–	4	–	14	–	–	2	L	—	L	—
Average	1.9	2.7	6.1	8.6	6.4	5.1	9.7	9.5	1.3	2.2				
Average for all	2.1	2.7	5.4	7.9	5.8	5.7	8.3	9.3	1.9	2.4				

the decrease for each foot. The left then showed 44 seconds of decrease in performance time and the right 1 second. The difference of 43 seconds or 5 units of leftness appear in the table. If the increase was greater than the decrease, the difference was recorded as zero.

In the individual analysis of the first group of 100 cases, data included 6 foot tests, 1 hand test and 2 eye measures. From the data on feet 10% of the cases showed no difference between the feet. For the group 33% of cases showed a preference for the left with an average of 8.3 units and 57% of cases preferred the right with an average of 9.3 units of rightness. The shortest trial comparison showed 26% with 2.1 units on the left and 62% with 2.7 units on the right and 12% with no difference between the sides. In the paired difference comparison 36% of cases preferred the left with an average of 5.4 units and 64% preferred the right with an average of 7.9 units. On the basis of rate of decrease 64% preferred the left and 35% the right with the average rate of decrease the same. The group showd clear right preference with evidence of quick left improvement. Tables XIII and XIV should be consulted.

Women showed no difference in preference and men a right preference in foot units. For total units the left foot was preferred by 28% of men and 38% of women, the right by 62% of men and 52% of women and no preference was shown by 10% of both sexes. On shortest trials men had 24% left preference, 70% right preference and 6% no preference while women had 28% left preference, 54% right preference and 18% no preference. On paired differences men had 34% left preference and 66% right preference while women had 38% left preference and 62% right preference. On rate of decrease men had 60% left preference and 38% right preference while women had 68% left preference and 32% right preference.

In the hand tapping test the data did not permit an estimate of rate of decrease. On the basis of shortest trials and paired differences, 16% of cases preferred the left with an average of 1.9 units and 81% the right with an average of 2.4 units. There were 13% of cases with the shortest trial units on the left side and 79% on the right side. The sexes showed little variation.

For all cases hand and foot units were on the left side in 5% of cases, on the right side in 48% and crossed in 34% of cases. Cases with zero units were omitted. Left-footedness and right-handedness occurred in 26% of cases and right-footedness and left-handedness in 8%. Hand and foot units were on the left side for 10% males and no females. Hand and foot units were on the right side for 58% males and 38% females. Crossed preferences were shown by 18% of males and 50% females. Left-footedness and right-handedness were shown by 16% of males and 36% females while right-footedness and left-handedness were shown by 2% males and 14% females.

On the two eye measures, the cone test and the use of the microscope, 86% of cases showed preference for the same eye on both tests with 55% having right preference and 31% left preference. Only 11% showed a varied preference on the two measures.

Eyedness and handedness were more often on the same side than eyedness and footedness. Eyedness in both tests and handedness were on the same side in 58% of cases with 50% of these on the right side and 8% on the left side. Eyedness in both tests and footedness were on the same side in 46% of cases with 35% of these on the right side and 11% on the left side. Eyedness in both tests and handedness were on opposite side in 29% of cases with 22% of these right-handed-left-eyed and 7% left-handed-right-eyed. Eyedness in both tests and footedness were on opposite sides in 33% of cases with 16% right-footed-left-eyed and 17% left-footed-right-eyed. Varied eye response was coupled with 8% of handedness and 9% footedness cases. There were zero differences between hands in 3% of cases and between feet in 10% of cases.

(2) Second Group of Subjects

Individual analysis of the second group of 90 students included data on 3 foot tests, namely the grasping, the manipulation and pressing tests; and 3 hand tests, namely the Seguin formboard with and without vision and the grasping test. Comparisons were based on three estimates as in the first group.

The combination of hand and foot units showed 49% of cases quicker with the left side with an average of 13.3 units and 49%

TABLE XV.

Individual Analysis of Data for Men of the Second Group on Motor Tests in Terms of Units of Difference in Leftness and Rightness

No.	Feet								Hands								F. & H.		Eyes			
	Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Difference Total		Peep-hole Test		Microscope	
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1.	1	—	16	—	10	—	27	—	2	—	—	2	3	—	3	—	30	—	—	R	—	R
2.	—	1	—	1	4	—	2	—	—	1	3	—	4	—	6	—	8	—	—	R	—	R
3.	1	—	5	—	—	7	—	1	3	—	—	4	2	—	1	—	0	0	—	R	—	—
4.	0	0	—	28	23	—	—	5	—	1	3	—	1	—	3	—	—	2	L	—	L	—
5.	—	3	5	—	5	—	7	—	—	1	2	—	4	—	5	—	12	—	—	R	L	—
6.	3	—	—	6	22	—	19	—	3	—	—	6	—	1	—	4	15	—	—	R	either	
7.	3	—	23	—	28	—	54	—	1	—	5	—	—	6	0	0	54	—	L	—	L	—
8.	1	—	—	2	—	15	—	16	—	1	2	—	—	11	—	10	—	26	—	R	—	R
9.	—	1	5	—	—	11	—	7	1	—	—	2	—	2	—	3	—	10	—	R	—	R
10.	—	3	6	—	13	—	16	—	1	—	1	—	3	—	5	—	21	—	—	R	—	R
11.	1	—	—	5	5	—	1	—	3	—	—	4	1	—	0	0	1	—	—	R	—	R
12.	—	1	9	—	—	5	3	—	—	3	8	—	—	3	2	—	5	—	L	—	L	—
13.	—	3	36	—	—	12	21	—	1	—	—	2	—	1	—	2	19	—	—	R	—	R
14.	1	—	—	28	—	4	—	31	—	2	3	—	—	4	—	3	—	34	—	R	—	R
15.	—	1	8	—	15	—	22	—	—	1	1	—	—	16	—	16	6	—	—	R	L	—
16.	1	—	6	—	—	2	5	—	0	0	1	—	5	—	6	—	11	—	—	R	—	R
17.	1	—	11	—	1	—	13	—	3	—	—	3	—	4	—	4	9	—	—	R	—	R
18.	—	2	3	—	—	10	—	9	—	3	7	—	—	14	—	10	—	19	—	R	—	R
19.	—	1	3	—	2	—	4	—	3	—	—	11	12	—	4	—	8	—	either		L	—
20.	—	3	10	—	6	—	13	—	1	—	4	—	—	8	—	3	10	—	L	—	L	—
21.	—	1	24	—	23	—	46	—	—	3	4	—	3	—	4	—	50	—	L	—	L	—
22.	—	3	14	—	—	26	—	15	1	—	—	5	—	2	—	6	—	21	L	—	L	—

21.	—	1	24	—	23	—	46	—	—	3	4	—	3	—	4	—	50	—	L	—	L	—		
22.	—	3	14	—	—	26	—	15	1	—	—	5	—	2	—	6	—	21	L	—	L	—		

No.	Feet								Hands								F. & H.				Eyes			
	Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Difference Total		Peep-hole Test		Microscope			
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
23.	0	0	—	12	16	—	4	—	—	1	5	—	—	1	3	—	7	—	L	—	L	—		
24.	1	—	—	5	—	8	—	12	—	1	1	—	—	21	—	21	—	33	—	R	L	—		
25.	—	1	20	—	—	7	12	—	—	1	2	—	—	3	—	2	10	—	—	R	—	—		
26.	3	—	9	—	11	—	23	—	1	—	1	—	—	4	—	2	21	—	—	R	either			
27.	—	2	—	14	5	—	—	11	1	—	—	3	4	—	2	—	—	9	—	R	—	R		
28.	3	—	9	—	1	—	13	—	1	—	5	—	9	—	15	—	28	—	L	—	L	—		
29.	—	2	—	5	0	0	—	7	0	0	6	—	—	2	4	—	—	3	—	R	—	R		
30.	1	—	—	12	4	—	—	7	—	1	—	2	—	6	—	9	—	16	L	—	L	—		
31.	—	1	—	3	—	6	—	10	—	2	5	—	—	2	1	—	—	9	—	R	either			
32.	—	2	6	—	5	—	9	—	—	3	2	—	3	—	2	—	11	—	—	R	L	—		
33.	—	1	1	—	9	—	9	—	—	3	2	—	—	16	—	17	—	8	—	R	either			
34.	1	—	9	—	—	1	9	—	0	0	5	—	—	3	2	—	11	—	—	—	either			
35.	—	3	11	—	—	3	5	—	—	2	14	—	—	6	6	—	11	—	L	—	—	R		
36.	2	—	—	1	11	—	12	—	1	—	—	18	0	0	—	17	—	5	—	—	—	—		
37.	—	2	13	—	—	31	—	20	—	1	—	4	5	—	0	0	—	20	—	R	—	R		
38.	1	—	—	2	9	—	8	—	0	0	6	—	—	13	—	7	1	—	—	R	—	R		
39.	1	—	1	—	18	—	20	—	3	—	—	3	1	—	1	—	21	—	—	R	—	R		
40.	1	—	—	1	—	11	—	11	1	—	—	5	5	—	1	—	—	10	—	R	either			
41.	1	—	1	—	13	—	15	—	1	—	—	1	—	1	—	1	14	—	—	R	—	R		
42.	3	—	1	—	18	—	22	—	1	—	1	—	—	5	—	3	19	—	L	—	L	—		
43.	1	—	12	—	—	4	9	—	—	1	—	3	3	—	—	1	8	—	—	R	—	R		
44.	—	1	14	—	—	2	11	—	—	1	1	—	—	8	—	8	3	—	L	—	—	R		
45.	1	—	—	13	20	—	8	—	1	—	—	25	2	—	—	22	—	14	L	—	L	—		
Average	1.5	1.8	10	8.6	11	9	14	12	1.6	1.7	4	6	4	6	4	8	15	15						

TABLE XVI.

Individual Analysis of Data for Women of the Second Group on Motor Tests in Terms of Units of Difference in Leftness and Rightness

No.	Feet								Hands								F. & H.		Eyes			
	Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Difference Total		Peep-hole Test		Microscope	
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
46.	—	2	2	—	—	2	—	2	3	—	1	—	1	—	5	—	3	—	L	—	L	—
47.	—	1	—	39	—	48	—	88	—	1	—	3	—	2	—	6	—	94	—	R	—	R
48.	1	—	—	9	—	23	—	31	—	1	—	2	0	0	—	3	—	34	—	R	—	—
49.	1	—	22	—	17	—	40	—	1	—	—	1	—	3	—	3	37	—	—	R	—	R
50.	—	1	—	1	3	—	1	—	—	1	—	3	5	—	1	—	2	—	L	—	—	—
51.	—	1	—	11	8	—	—	4	1	—	—	15	9	—	—	5	—	9	—	R	—	R
52.	3	—	4	—	5	—	12	—	1	—	2	—	—	13	—	10	2	—	L	—	L	—
53.	1	—	—	7	—	3	—	9	—	1	—	9	15	—	5	—	—	4	—	R	L	—
54.	—	1	—	13	1	—	—	13	3	—	7	—	—	12	—	2	—	15	L	—	L	—
55.	—	3	—	17	—	8	—	28	3	—	15	—	3	—	21	—	—	7	—	R	—	R
56.	0	0	—	4	13	—	9	—	0	0	—	1	1	—	0	0	9	—	—	R	—	R
57.	3	—	2	—	—	4	1	—	1	—	7	—	1	—	9	—	10	—	—	R	—	R
58.	1	—	5	—	6	—	12	—	—	1	—	7	—	6	—	14	—	2	—	R	L	—
59.	1	—	—	1	1	—	1	—	1	—	1	—	—	1	1	—	2	—	—	R	—	R
60.	—	3	—	17	—	1	—	21	3	—	3	—	—	4	2	—	—	19	—	R	L	—
61.	1	—	5	—	22	—	28	—	0	0	2	—	11	—	13	—	41	—	—	R	—	R
62.	—	1	—	13	—	9	—	23	—	3	—	12	—	19	—	34	—	57	—	R	—	R
63.	—	1	—	1	—	13	—	15	1	—	—	1	—	3	—	3	—	18	—	R	—	R
64.	1	—	2	—	1	—	4	—	—	3	—	8	4	—	—	7	—	3	—	R	L	—
65.	—	1	—	4	3	—	—	2	—	1	2	—	3	—	4	—	2	—	—	R	—	R
66.	—	1	—	4	—	7	—	12	—	2	—	17	—	5	—	24	—	36	—	R	—	R
67.	0	0	1	—	0	0	1	—	—	1	—	5	—	4	—	10	—	9	L	—	L	—
68.	3	—	1	—	5	—	9	—	—	3	—	2	—	8	—	13	—	4	—	R	either	

67.	0	0	1	—	0	0	1	—	—	1	—	5	—	4	—	10	—	9	L	—	L	—		
68.	3	—	1	—	5	—	9	—	—	3	—	2	—	8	—	13	—	4	—	R	either			

No.	Feet								Hands								F. & H.		Eyes			
	Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Shortest Trial		Paired Difference		Rate of Decrease		Difference Total		Difference Total		Peep-hole Test		Microscope	
Subject	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
69.	1	—	11	—	—	5	7	—	—	1	—	3	—	4	—	8	—	1	L	—	L	—
70.	3	—	27	—	—	15	15	—	1	—	1	—	—	20	—	18	—	3	—	R	—	R
71.	—	3	—	26	13	—	—	16	—	3	—	25	—	16	—	44	—	60	L	—	L	—
72.	—	1	—	19	—	4	—	24	—	1	—	3	10	—	6	—	—	18	—	R	—	R
73.	0	0	7	—	7	—	14	—	—	1	—	7	7	—	—	1	13	—	—	R	—	R
74.	1	—	—	4	—	17	—	20	3	—	15	—	—	9	9	—	—	11	L	—	—	—
75.	0	0	4	—	—	7	—	3	3	—	9	—	2	—	14	—	11	—	—	R	—	R
76.	—	3	—	8	—	14	—	25	—	1	—	5	—	3	—	9	—	34	—	R	—	R
77.	—	1	—	13	—	5	—	19	2	—	14	—	0	0	16	—	—	3	—	R	—	—
78.	1	—	—	14	—	1	—	14	3	—	2	—	6	—	11	—	—	3	—	R	—	R
79.	—	3	—	6	14	—	5	—	—	3	—	4	10	—	3	—	8	—	L	—	L	—
80.	1	—	—	8	—	5	—	12	3	—	5	—	—	9	—	1	—	13	L	—	L	—
81.	3	—	3	—	—	6	0	0	1	—	—	3	10	—	8	—	8	—	—	—	—	R
82.	—	1	—	7	5	—	—	3	2	—	3	—	4	—	9	—	6	—	L	—	L	—
83.	—	3	—	13	5	—	—	11	2	—	2	—	3	—	7	—	—	4	—	R	—	R
84.	—	1	1	—	0	0	0	0	—	1	—	2	2	—	—	1	—	1	—	R	—	R
85.	—	3	—	16	—	9	—	28	1	—	—	6	5	—	0	0	—	28	—	R	—	R
86.	—	3	—	8	—	9	—	20	3	—	7	—	1	—	11	—	—	9	—	R	—	R
87.	—	1	—	1	9	—	7	—	1	—	—	9	2	—	—	6	1	—	—	R	L	—
88.	—	1	—	23	15	—	—	9	0	0	12	—	5	—	17	—	8	—	L	—	—	R
89.	—	1	—	6	16	—	9	—	—	2	—	6	—	2	—	10	—	1	—	R	—	R
90.	—	1	1	—	—	2	—	2	1	—	2	—	—	1	2	—	0	0	—	R	L	—
Average	1.6	1.7	6	11	8	9	10	17	1.9	1.6	6	6	5	7	8	11	10	18				
Average for all	1.6	1.7	9	10	10	9	13	15	1.8	1.6	5	6	5	7	6	9	13	17				

quicker with the right side with an average of 16.8 units. The sexes represented a complete reversal of preferences which the totals for the entire group do not show. Of the men 62% were quicker with the left side with an average of 15 units and 36% were quicker with the right side with an average of 15 units. Of the women 36% were quicker with the left side with an average of 10 units and 62% were quicker with the right side with an average of 18 units. This variation was due to the difference in feet not hands. Tables XV and XVI should be consulted.

For the total foot units alone 53% of cases were quicker with the left foot with an average of 13 units and 44% were quicker with the right with an average of 15 units. Of the men 69% were quicker with the left with an average of 14 units and 31% were quicker with the right with an average of 12 units. The women had 38% quicker with the left foot with an average of 10 units and 58% with the right foot with an average of 17 units. In rate of decrease men had more cases gaining faster with the left foot and women with the right foot. The paired difference comparison showed 64% of men quicker with the left foot and 64% of women quicker with the right foot. The shortest trial comparison showed little difference between the feet for men but women had more shortest trials on the right side. This comparison showed very well the remarkable modification by foot usage in the case of men.

The total hand units showed 46% of cases quicker with the left hand with an average difference of 6 units and 49% quicker with the right hand with an average difference of 9 units. The percent of cases favoring either side were quite similar for the two sexes but men showed the right hand with more units of difference than the left. Of the men 44% were quicker with the left hand with an average of 4 units and 49% with the right hand with an average of 8 units. Of the women 47% were quicker with the left hand with an average of 8 units and 49% with the right hand with an average of 11 units. The nature of the hand tests in this series tended to favor the left hand for both sexes.

Footedness and handedness were on the same side in 40% of cases with 21% of cases on the left side and 19% on the right side. Two-thirds of the men with both on the same side, had them on the left

side while two-thirds of the women with both on the same side, had them on the right side. Footedness and handedness were on opposite sides in 52% of cases with 29% of cases left-footed-right-handed and 23% right-footed-left-handed. In 8% of cases zero differences occurred in either hand or foot.

Eyedness on both tests and footedness were on the same side in 45% of cases with both on the left in 16% and both on the right in 29% of cases. Eyedness and footedness were on opposite sides in 37% of cases with 27% of left-footed-right-eyed and 10% of right-footed-left-eyed cases. In 15% of cases eyedness varied on the two tests.

Eyedness on both tests and handedness were on the same side in 41% of cases with 12% on the left side and 29% on the right side. Eyedness and handedness were on the reverse sides in 38% of cases with left-handed-right-eyed cases in 26% and right-handed-left-eyed cases in 12% of cases. In 14% of cases eyedness varied on the two tests.

(3) Comparison of Test Results of the Two Groups

About a year elapsed between the two series of tests. This small amount of practice in comparison with the previous early life practice of the subjects did not explain the varied results on the two series so well as the nature of the testing situation. In the two groups 62 cases were the same with 29 of these men and 33 women. In the two series of tests 31% of cases showed the same footedness on both with 13% of these left and 18% right. However 69% of cases reversed footedness on the two series. In the two series 47% of cases showed the same handedness on both with 8% left and 39% right. In contrast 53% of cases changed handedness. Reversal of footedness was more frequent than handedness reversals.

Table XVII gives the percent of cases showing differences of units on the two sides for feet and hands in the two series of tests. The first series of foot tests for men definitely showed about two-thirds of the cases favoring the right foot. The pegboard test was usually significantly easier for the right foot than the left. The second series for men practically reversed the results since this series very definitely

TABLE XVII.

Comparison of the Two Series of Laterality Tests for the Same Individuals in Terms of Percent of Cases with More Units on a Given Side

	Feet				Hands				Feet and Hands			
	Left		Right		Left		Right		Left		Right	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Men												
First series	7	24	18	62	5	17	23	79	9	31	20	69
Second series	20	69	9	31	15	52	12	41	19	66	9	31
Women												
First series	14	42	15	45	4	12	28	85	12	36	19	58
Second series	15	45	17	52	15	45	17	52	14	42	19	58
All cases												
First series	21	34	33	53	9	15	51	82	21	34	39	63
Second series	35	56	26	42	30	48	29	47	33	53	28	45

* Cases with zero differences are omitted in table.

favored the left foot. Apparently among men certain athletic practices of balancing on the left foot showed up in the second series. The foot units for women on the two series did not show this great variation and were fairly consistent. In the first series the only hand test of tapping gave a high right preference for both sexes but the second series of hand tests definitely favored the left hand, slightly more in the case of men than women. The first hand test of tapping was not a difficult coordination but the length of the test through the element of fatigue showed up the weaker hand readily. The tests of the second series for hands involved reversal of the formboard without vision and gave the left hand the more used direction of left to right while the right hand had the right to left movement. In a crude way the cross movement tests and the grasping-transfer foot tests showed this to be a factor in such tests.

The comparison of the two series of tests definitely showed the great importance of analyzing the test situation for both feet and hands. Tests that involved continued long repetition of a single movement with subsequent fatiguing of the weaker member, such as the tapping test and tests that involved great precision of control like the pegboard test seemed definitely to favor the right side. Tests that did not involve these two elements might favor either one side or the other somewhat according to the practice effects of everyday living as the variation of sex response so well indicated on the foot tests. Such factors as the habitual directional movement and clockwise movements with and without vision need further investigation in relation to laterality.

9. *Summary of Results*

1. Results of Motor Tests for Feet

Gross motor foot tests were poor measures of lateral preference since they were readily modified by handedness, since they represented lateral preference as dichotomy rather than a gradation and since they often failed to differentiate the feet. The right foot was preferred in only 3 of 7 tests. An average of all cases showed the left preferred by 41% of cases and the right by 59% but this was greatly influenced by the right preference in one of the tests. The great

variation in the response of the sexes indicated the great importance of practice factors. On all seven tests women had 34% of cases quicker with the left and 65% with the right while men had 46% quicker with the left and 52% with the right.

The specific tests showed the right foot to be superior to the left in terms of mean, midscore, sigma and percent of preference. A comparison of means in Table II showed the right foot to be quicker in 7 of 10 tests with the difference ranging from 1 to 35 seconds while the left was quicker in only 3 tests with differences ranging from 0.4 to 2.6. The average of the 10 means was 92 seconds for the left and 85 seconds for the right. A similar comparison of midscores showed them to be the same in two tests. The right foot was quicker in 7 tests with a difference ranging from 1 to 43 seconds. The average for the midscores was 85 seconds for the left and 77 for the right. Not only were left feet slower than right but they showed greater variability in performance. Sigma for the left side was greater in 6 tests with the difference ranging from 0.8 to 23.7. In the four tests in which sigma for the right side was greater than the left, the difference ranged from 0.6 to 5.4. On the 10 tests sigma for the left averaged 38.5 and for the right 34.5. From Table V the percent of preference showed the right side preferred in 7 of the 10 tests with differences between the sides ranging from 7 to 34 while the left side was preferred in 3 tests with differences between sides ranging from 1 to 18. The average for the percent of preference on the 10 tests was 42% for the left and 55% for the right. Various factors in three tests, the grasping-carrying, the Seguin formboard and the pressing test seemed to favor the left foot. With these omitted the percent of preference for the sides became 38% for the left and 59% for the right. Three best tests averaged 34% for the left and 63% for the right. These three tests in order were the inverted bowl test without vision, the Wallin pegboard test with vision and the tapping test with vision.

A significant difference in laterality may be noticed from the totals of seconds saved by the preferred foot in Table VI. The average saving in seconds for the 36% of cases quicker with the left side was 48.8 seconds while the 64% of cases with a quicker right performance saved an average of 74.1 seconds. A similar summary of

the seconds saved in the three tests without vision, based on Table IX showed that the 36% of cases quicker with the left foot averaged 69.3 seconds saved while the 64% quicker with the right foot averaged a saving of 99.1 seconds. On the two sets of data the percent of cases favoring the left and right were identical and the saving similar. In the first set the right feet showed a saving of 25.3 seconds over the left and in the second the right had a saving of 29.8 seconds over the left.

To summarize briefly, specific motor tests showed the right foot to be quicker in response, more uniform in response and preferred on fine coordinations or long continued activities by nearly two-thirds the cases.

The lack of vision was not important in simple movements but produced a significant increase in time and variability of performance in complex movements. The difference between left and right means on the inverted bowl test was double that on the pegboard test. Sigmas increased greatly, especially for the left foot. In the inverted bowl test there was a significant increase of right preferences over any of the tests with vision. Lack of vision seemed to adversely affect the performance of men, by increasing their time of performance and their variability. In most of the tests with vision men had been quicker than women in mean performance; on the complex motor tests without vision men were significantly slower than women. Test results did not indicate whether men were more thwarted by the situation or less well orientated without vision.

Sex difference on the tests indicated for the most part that women showed a stronger tendency for right preference than men. Although the means for both sexes showed the right foot required less time than the left in 8 of the 10 tests, the means for women showed somewhat greater difference between the left and right feet than in the case of men. From Table XI the difference between the average of the percent of cases favoring the left and right was about 9% more males favoring the right than the left while there were 16% more females favoring the right than the left. Sigma for men was greater for the left foot than the right in 7 of 10 tests while sigma for women was greater for the left foot in only 5 of 10 tests. The average for sigma on all 10 specific tests was slightly larger in the case of men

than women for both feet. The average of sigma for men's left feet was 41.0 and for women 34.6; this average for men's right feet was 35.4 and for women's 32.0. The slightly greater right efficiency in women might be interpreted as a continuation of an earlier right trend unmodified by practice. Men on the other hand by practice effects of a more active life with greater use of the left foot in balancing, have brought their left feet more nearly to the efficiency level of the right.

Women's feet for the most part were slower than men's in most of the tests. Women's feet were slower than men's in the case of 6 of the 10 left means and 7 of the ten right means. Women's left feet varied more from men's left feet than they varied in the case of the right side. Results of such a test as the grasping-carrying in which women's left feet were quicker than men's left feet were due to specific factors, such as a possible directional preference and the easier grasping of round objects by the weaker foot. On the whole the slower performance of women's feet was best explained in terms of the kind of shoes the two sexes wear.

The fact that women were more efficient with both feet in the two difficult foot tests without vision could be interpreted either as better orientation without vision in the case of women or as greater frustration with inhibitory effects in the case of men.

(2) Results of Motor Tests for Hands

Gross motor tests of hands showed the right preferred in 60% or more of the cases for 7 of 10 tests with the other 3 tests definitely favoring the left arm. Performance of the sexes was very similar on these tests.

Gross motor hand tests showed a clearer right preference than in the case of gross motor foot tests. The average of the percent of preference for the tests showed the right hand preferred by 79% of cases in 7 tests and the right leg by 59% of cases in 10 tests. Hand and foot preference in women tended to be more alike than in the case of men. Men preferred the left hand in 18% and the left foot in 46% of cases while the right hand was preferred in 82% and the right foot in 52% of cases. Women preferred the left hand in 23%

and the left foot in 34% of cases while the right hand was preferred in 76% and the right foot in 65% of cases.

The 4 specific motor tests were rather poor measures of handedness due to various other factors in the testing situation. The tapping test, however, gave consistent right preference with both sexes. The Seguin formboard with vision favored the left side in the case of both hands and feet due either to variation of placement of forms or directional movements. Lack of vision of the formboard introduced an unusual sex variation with men showing continued left preference and with women changing to a right preference. The grasping-transfer without vision introduced a sex difference with men showing more efficient right performances and women more efficient left performance due more to the relaxed feminine hold on round objects than to lack of vision. Despite these varying factors right means were smaller than left ones in 3 of 4 tests. Three right midscores were also smaller than left ones. Sigma was the same in two tests and greater for the left hand in two tests. The right hand was preferred by more cases in two tests and the left in two tests.

Specific motor hand tests showed a stronger preference for the right side than specific motor foot tests. From Tables V and XI left hands were preferred in 34% of cases and right hands in 64% while left feet were preferred in 42% and right feet in 55% of cases. Thus right hands were preferred 30% more often than left while right feet were preferred only 13% more often than left. The average of right foot means was 7 seconds less than left while right hand means averaged only 3 less than left ones.

(3) Results of Ear and Eye Tests

A left ear preference was shown by 45.5% of cases and a right preference in 54.5%.

An average of the 4 eye tests showed the group to have 34% preference for the left eye and 63% preference for the right eye.

(4) Results of the Individual Analysis

Analysis for the first group of subjects showed that 10% of cases had no difference between the feet, that 33% had a left preference

with an average of 8.3 units and 57% had a right preference with an average of 9.3 units. The group had a definite right preference in foot usage with evidence of quick left improvement. The left foot was preferred by 28% of men and 38% of women and the right foot by 62% of men and 52% of women.

Group one had only the hand tapping test which resulted in a 16% left preference with an average of 1.9 units and 81% right preference with an average of 2.4 units.

Hand and foot units in group one were on the left side in 5% of cases, on the right side in 48% and crossed in 34%. Eyedness on both tests and handedness were on the same side in 58% of cases with 50% of these on the right side. Eyedness on both tests and footedness were on the same side in 46% of cases with 35% of these on the right side.

The second group had 53% of cases quicker with the left foot with an average of 13 units and 44% quicker with the right with an average of 15 units. More left units were shown by 69% of men and 38% of women while more right units were shown by 31% of men and 58% of women.

On hand units alone the second group had 46% with an average of 6 units on the left side and 49% with an average of 9 units on the right side.

Footedness and handedness for the second group were on the same side in 40% of cases with 21% of these on the left side. Eyedness and footedness were on the same side in 45% of cases with 29% of these on the right side. Eyedness and handedness were on the same side in 41% of cases with 29% of these on the right side.

A comparison of the results of the two series indicated the need of a careful analysis of testing situations and the great adaptability of both sides in any learning situation.

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